Fisheries Stock Assessment in the Traditional Fishery Sector:
The Information Needs

Proceedings of the National Workshop on the Artisanal Fisheries Sector, Zanzibar. September 22-24, 1997 Zanzibar, Tanzania

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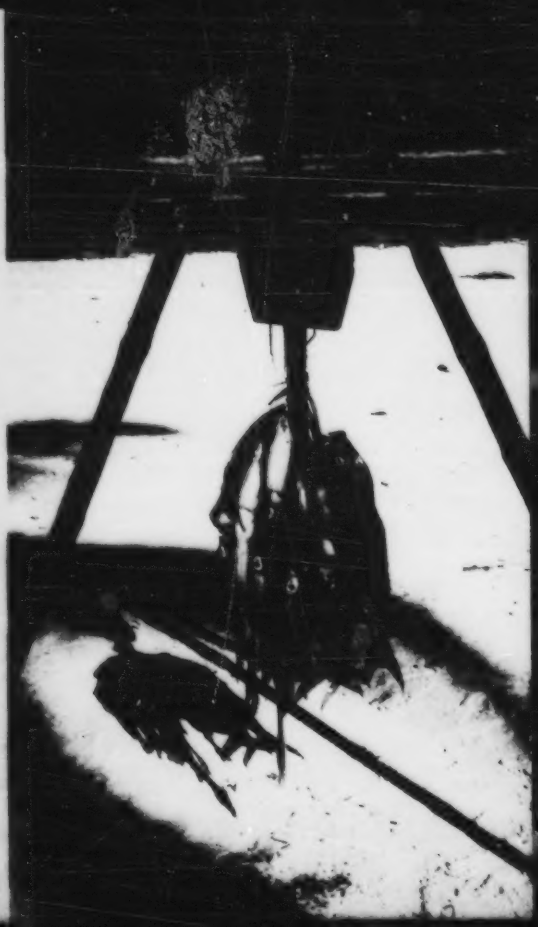

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The National Workshop on the Artisanal Fisheries Sector was held at the Fisherman's Resort, September 22-24, 1997, Zanzibar, Tanzania. The workshop was sponsored by the Canadian International Development Agency (C.I.D.A.) through the contractor, LGL Limited, and hosted by the Institute of Marine Sciences (I.M.S.), University of Dar es Salaam. The workshop was part of the Fisheries Stock Assessment Sub-Project of the I.M.S./C.I.D.A. project: Assistance for the development and management of coastal and marine resources of Zanzibar, Tanzania, Project 890336, Zanzibar Fisheries Project.

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Introduction

The importance of the fisheries of Zanzibar is obvious even to the newly arrived tourist, yet while critical to the prosperity of the Tanzania, management of these resources is hampered for many reasons. Among these, is the lack of accurate harvest information. The current program may provide sufficient data to broadly categorise harvest and usage patterns but it is not sufficient to monitor statistics like catch rate and species composition such that they can be used to monitor resource status. While everyone acknowledges the value of tracking fishery landings over time, data collectors and managers are rarely provided with sufficient resources to capture the data.

Because of the shortage, government agencies have attempted to solely rely on large-scale data collection systems that attempt to cover all or most landings. But the limited budgets fail to provide the critical mass of resources need for successful implementation and maintenance of comprehensive census-style capture of harvest and fishing effort information (Wright and Hill 1993). The problem is not unique to Zanzibar.

> "Attempts have been made to establish statistical systems to monitor the artisanal fisheries in many tropical countries but we know of no example of sustained successful implementation. The problems of dispersed landings, the multitude of species, variations in fish prices and of unrecorded subsistence catches normally combine to make the systems inaccurate and inordinately expensive in terms of manpower. Additionally, the fact that most tropical fisheries are also multigear fisheries makes the derivation of any but the crudest expressions of fishing effort almost impossible. The result has been that few meaningful or beneficial results have ever been perceived to emerge from statistical systems in multispecies, multigear fisheries, and there has been strong tendency to scale-down the work to meaningless levels or abandon it altogether." (Munro and Fakahau 1993)

A second part of the problem lies in the assumption that once such systems are in place, they can continue to operate on autopilot with little critical review. Finally, implementation of such systems is hampered by the fishing community's distrust of such programs, believing them to be the leading edge of new taxes or restrictive fishing regulations.

An alternative approach is to use small-scale point studies to develop highly accurate and detailed data sets. But, while these studies typically provide more accurate data, unless they are designed from outset to be used for extrapolation to broader areas or to supplement broader studies, they tend to lack the breadth to answer the more general questions required by government planners.

To address these problems in the collection of fishery data in Zanzibar and focus attention on improving current methods, the Institute of Marine Sciences (I.M.S.), University of Dar es Salaam, hosted a workshop in Zanzibar, Tanzania, September 22-24, 1997 . It was entitled "Fisheries Stock Assessment in the Traditional Fishery Sector: The Information Needs".

The workshop was funded by the Canadian International Development Agency (C.I.D.A.) through the Zanzibar Fisheries Project (I.M.S./C.I.D.A.) and attended by 30 people including many from the Tanzanian mainland. Government agencies from Zanzibar that were represented included the Zanzibar Sub Commission of Fisheries, the Zanzibar Department of the Environment and the Zanzibar Department of Statistics. Also present were representatives from Tanzanian Fisheries Research Institute, Mafia Island Marine Park, Department of Fisheries (Dar es Salaam), Tanga Coastal Zone Conservation and Development Programme, National Environmental Management Council (N.E.M.C.), African Fishing Company, Frontier-Tanzania Marine Research Programme, Conservation and Development Corporation of Zanzibar, Foundation Oceania International, and the Western Indian Ocean Marine Science Association (W.I.O.M.S.A.).

By bringing together the people and agencies responsible for collecting and using fishery data, the objectives of the workshop were to:

- raise the profile of fishery data collection activities and emphasise that data collection was an important job rather than a bureaucratic nuisance;
- provide examples of different data collection approaches that were being used in Tanzania and discuss the relative strengths and weaknesses of each approach;
- provide case studies of how the data were used to provide management advice.

The Honourable Issa Mohammed, Minister of Information, Culture, Tourism and Youth for Zanzibar, officially opened the workshop. Participants presented 25 papers on various aspects of the artisanal sector. Each paper was followed by a brief discussion. During the final afternoon, participants divided into three discussion groups to discuss and summarise for the plenary session, the issues of (1) fisheries data collection; (2) current problems in fisheries management; and

(3) fishery development and promotion. Following summary comments by Mr. Richard D. Stanley, the workshop was officially closed by Mr. Saleh Sadik Othman, former trustee of the W.I.O.M.S.A. and currently Principal Secretary of the Ministry of Health. We believe that the workshop was successful in emphasizing the role of fishery data collection and the suggestions and recommendations provided in the papers and discussions will lead to progress in the collection and analysis of these data. Participants affirmed that these data are essential for understanding the dynamics of Tanzania's fishery resources and therefore management. Participants stressed that there are numerous fishery resource issues that cannot wait any longer for remedial action and urged government and non-governmental agencies to press for action. All agreed that there are numerous initiatives underway which will address many of these issues.

The present publication includes all presentations that were received in the written form by the editors. They have been edited to be consistent in format and style. Data summaries, analyses, and citations were the responsibility of the authors and not the editors. However, in the interests of consistency and because most authors did not include the total number of pages in book citations, we chose the editorial style (for example American Fisheries Society guideline for authors) which omits number of pages for books. They have been retained for journal references.

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Opening Address

Mr. Chairman, distinguished participants, ladies and gentlemen:
I am pleased to be here with you today to officiate at the opening ceremony of this important national workshop on the artisanal fisheries sector. I would like to thank the organisers of the workshop, the Institute of Marine Sciences, for extending an invitation to me to be here amongst such a distinguished group of participants from as far away as Canada, the United Kingdom and different parts of Tanzania. Let me extend a warm welcome on behalf of the Government of Zanzibar and on my own behalf to all the delegates. These days, to decide to travel and participate in a workshop or a meeting at the expense of many other duties demonstrates the priority that one attaches to that meeting. The fact that so many of you are here today, provides evidence of the importance accorded to this workshop and deserves my utmost appreciation and commendation.

For some of you this is probably your first time to Zanzibar but to others it has become your second home. Such a gathering is, among other things, an excellent opportunity for people to meet and exchange ideas as well as to become personally acquainted with one another and thereby promote mutual understanding among nations. To all of you I say *Karibu sana* and wish you an enjoyable stay.

The theme of the workshop is stock assessment and management of the artisanal fisheries. These fisheries constitute more than 95% of the total marine fish catch. This means that the artisanal fisheries are a critical source of food, employment and income to most of the coastal communities. However, the fisheries sector of this country is in crisis! On the one hand, demand for fish products is steadily rising while on the other hand, the fish populations and the health of the marine ecosystems, on which they depend, appear to be in trouble. Fisheries statistics show that the annual fish catch for Zanzibar has declined from 16,500 t in 1987 to less than 8,000 t in 1991. During the same period, the number of fisherfolk has almost doubled. Several activities such as over-exploitation of resources, the use of destructive fishing gears and methods such as blastfishing, and the extraction of live corals for lime-burning and construction are threatening the very survival of the sector itself.

Mr. Chairman, when talking of artisanal fisheries, I also feel we can not avoid mentioning the great threat to our marine and coastal resources posed by other human activities. Let me, therefore, take this opportunity to make a brief mention of the problem. This is especially important given that Zanzibar is a country of islands composed of, and surrounded by, coral reef, and that the main exploiters of its marine resources are the local fisherfolk. It is very unfortunate that with

the focus on tourism development, the problem should inevitably get worse. Yet we need tourism, and we should continue to develop and promote tourism, especially eco-tourism, for the betterment of our people and the country's economic progress.

A very interesting fact is that fisheries, tourism and the environment are inseparable. While fisheries and tourism sometimes play a highly destructive role in the marine coastal environment, their prosperity is very much dependent on the well being and beauty of the sea. Therefore, it is urgent that profound remedial and precautionary measures be developed to conserve and protect the marine life and coastal environment. They must not be destroyed in the name of fisheries and tourism development.

Mr. Chairman and dear participants, this is not an easy job, I know! But we have to commit ourselves to the task. Because of the implications to the livelihood and future of our people and country, I would once again like to take this opportunity to ask the international community and related organisations to extend their help. We need their support for our national initiatives on the conservation of marine and coastal environment so that effective and efficient programmes can be conducted.

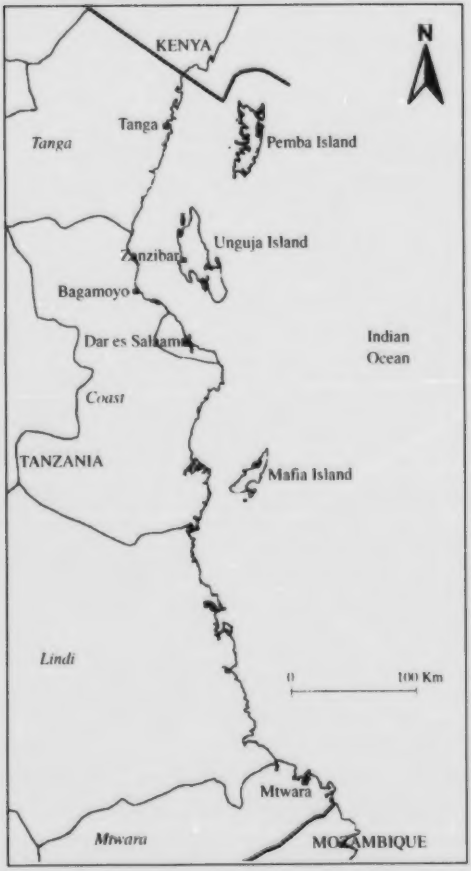
I am sure, Mr. Chairman, that this workshop will pursue these issues in greater detail. With these comments, I have attempted to provoke discussion within the workshop. It is my hope that this workshop, which involves academicians and policy makers as well as fisheries officers in the field, will go beyond identifying these problems and actually provide workable recommendations for gradual implementation at local as well as national levels.

Mr. Chairman, in addressing the problem currently facing the artisanal fisheries sector, the importance of data and information on fisheries resource in Tanzania waters cannot be overstated. For the policy makers to develop appropriate policies for sustainable utilisation of fisheries resources, the existence of comprehensive, accurate, and accessible data and information on these resources is critical. I am pleased to report that the Sub Commission of Fisheries is currently reviewing its data collection systems with the intention of increasing data reliability. This is an excellent step. We could also consider collecting data from fisherfolk themselves whose knowledge base spans many generations. This knowledge should be tapped and used for management of the resources. The importance of research in the success of any sector can not be over-emphasised. In this regard, it is critical that trained personnel in the research and fisheries training institutions are conducting applicable research towards solving fisheries problems.

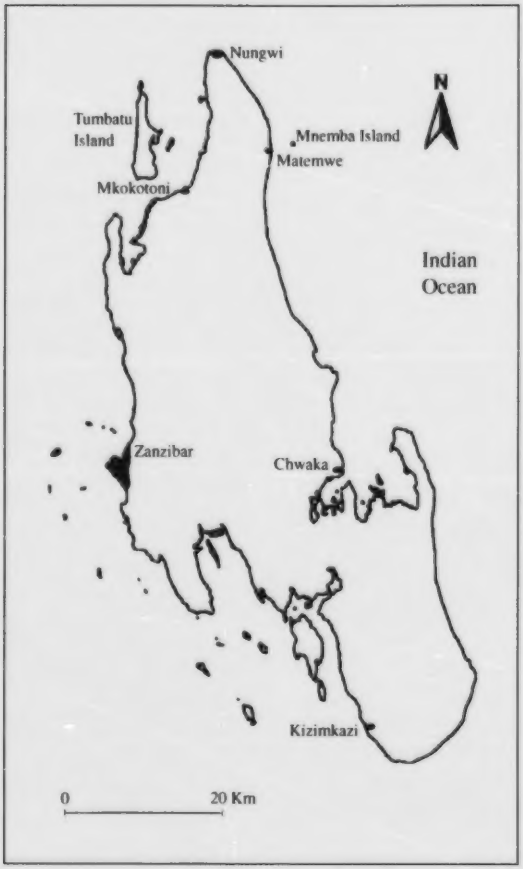
Mr. Chairman, ladies and gentlemen, I have been informed that this Workshop has been organised with the kind support of the Canadian International Development Agency (C.I.D.A.) through contract assistance from LGL Ltd. To them I wish to express my most sincere gratitude. I also appreciate the efforts of the staff of the Institute of Marine Sciences of the University of Dar es Salaam for hosting this workshop. To our guests from the mainland and overseas, I hope you will enjoy your stay here in Zanzibar and get an opportunity to make the spice tour or visit various historical sites, and enjoy Zanzibar cuisine. I am confident that your recommendations in this workshop will provide valuable guidance for the policy makers in the country and the region in general. With these few remarks, Mr. Chairman, I wish you much success with your deliberations and look forward to a fruitful conclusion. I now have the pleasure to declare the National Workshop on the Artisanal Fisheries Sector officially open.

Thank you.

Honourable Issa Mohammed Issa,
Minister of Information, Culture, Tourism and Youth, Government of Zanzibar



Map 1. Coastal Tanzania



Map 2. Unguja Island

Section 1: Regional Summaries of Artisanal Fisheries Data

Zanzibar artisanal fisheries sector: the status of demersal fisheries of Zanzibar *Issa A. Suleiman*

INTRODUCTION

This paper will discuss the artisanal fisheries sector in relation to the demersal fishery in Zanzibar. The term artisanal or small-scale fishery is perceived differently in different parts of the world; thus there is no adequate and generally accepted definition of an artisanal fishery. Hence fisheries have been classified in various ways (Haywood and Palfreman 1994):

- "small" and "large" scale;
- artisanal and commercial;
- inshore and offshore;
- by vessel size (Indonesia, Philippines);
- by gear type (Thailand);
- by distance from shore (Hongkong, Singapore);
- or, any combination of the last three.

Use of these terms, however, can be misleading because of the mix of vessels and gears in many fisheries. It is not unusual for what is considered to be a small-scale fishery in one country to be classified as large-scale in another. Moreover, the incomes and lifestyles of some of the owners of the small boats may be better than those fisherfolk who operate larger vessels. Despite these differences, however, there is widespread agreement that the contribution by the artisanal fisheries to the world fish production is large with total annual catch estimates of 20 million tonnes and employment estimated at 10-12 million people (FAO 1991).

Artisanal fisheries of Zanzibar

According to the definitions given above, Zanzibar artisanal fisheries can be classified into inshore and offshore as well as by vessel type. The most important area for the demersal fisheries is the inshore region (shallow territorial waters and the continental shelf waters). These waters contain significant marine resources and exhibit a high biological diversity. Important groups include shark, snapper, grouper, bream, rabbitfish, parrotfish, goatfish, mullet, octopus, squid, lobster, crab, and sea cucumber. There are extensive coral reef and mangrove habitats. The most popular fishing areas are near Latham Island, Menai Bay, Chwaka Bay, Mnemba Island, Matumbini Reefs, Misali Island, Mtangani Island, Makoongwe Island, and reefs to the northeast of Ras Kiuyu and Northeast Bay.

Fisherfolk, boats, and gear

Zanzibar artisanal fisheries play an important role in providing income (both local and foreign) and employment to a large number of fisherfolk. Their families form part of the poorest and most disadvantaged communities in the society. There are about 23,000 fisherfolk and approximately 2,500 fish traders. The total number of people employed in the fisheries sector, including dependents, is estimated to be about 14% of the population of Zanzibar (FAO 1995). The most important landing area is the urban area around Zanzibar City.

There are about 14 categories of artisanal fisheries based on the type of fishing vessel and gear used by the artisanal fisheries. Of these, eight are used for demersal species (Table 1). Some of the fishing gears and techniques are destructive to the fishing environment and harmful to fish, particularly the younger stages.

Table 1. Number of fishery units (Hoekstra *et al.* 1990)

Gear	Unguja Island	Pemba Island	Total
Fixed trap	82	33	115
Movable trap	658	481	1,139
Demersal gill net (small mesh)	173	228	401
Demersal gill net (large mesh)	79	73	152
Handline and surrounding nets	68	162	230
Lobster diving	129	25	154
Octopus spearing	435	703	1,138
Unknown	3	0	3
Total	1,627	1,705	3,332

The types of boats used in the nearshore waters include dugout canoes *(mtumbwi)*, outrigger canoes *(ngalawa)*, planked boats such as the dhow *(dau)* or *mashua* (Table 2). The parastatal fishing company, ZAFICO, uses aluminium seine vessels.

Table 2. Number of fishing units by boat type (Hoekstra *et al.* 1990)

Vessel	Unguja Island	Pemba Island	Total
Canoe	330	1,139	1,469
Outrigger canoe	1,305	303	1,608
Dhow	349	27	376
Mashua	207	73	280
Aluminum seiner	5	2	7
No boat	760	609	1,369
Total boats	2,196	1,544	3,740
Grand Total	2,956	2,153	5,109

Gillnets are used in tidal, subtidal and reef areas to capture fish moving with the tides. They are also used in streams. The nets usually consist of four to seven

panels of 2-inch mesh. Seines of small mesh size (0.5-4.5 inches) are used on the beach or from vessels. This gear is very destructive to corals and young fish or eggs as well as sea grass beds. Included in this category is *kigumi* fishing, known elsewhere as drive-net fishing or *muro-ami*.

Trap fishing is common in most of Zanzibar. The raw materials for the traps are locally available. The traps are usually set in seagrass beds, among wild or cultured seaweeds, or coral reefs. Trap fishing is less destructive to the environment and fish resources. Spearfishing is restricted by law owing to its impact on the fish resources and the environment. Usually it is conducted in coral reef areas to catch lobster, squid and snapper. Octopus, ornamental shell and sea cucumber collection is conducted by hand, often with sticks or speargun. Women, children and older people participate in this type of fishing.

Species Composition in the demersal fishery

Zanzibar coastal waters have a variety of fish habitats including the aquatic ecosystems associated with mangroves, estuaries, tidal flats, seagrass beds, and coral reefs. This leads to the wide diversity of species referred to above. Snapper are the most important, followed by parrotfish. The least important in the list, mullet, is the fish species that is considered to be overfished by most fishing communities in Zanzibar.

Factors affecting the artisanal fisheries sector

We need to increase fish production for both local and export markets, yet output is still below the national demand for fish, shellfish and other fishery products. Current government policy has targeted a production of 30,000 t/year (Anon. 1985) but 1995 annual production is only 10,025 t and appears to be declining. Almost all the Zanzibar communities have reported the decline and several indicators support the decline. These include catch statistics that show a declining trend in landings and the disappearance of fish such as milkfish.

Discussions with several fishing communities have indicated that in some localities, the catch rate of demersal species such as octopus, snail (for shells), sea cucumber and other intertidal organisms are declining (Robert 1990). However, there are no reliable or sufficient data on these resources despite their importance to the coastal communities. The apparent decline in landings may be the result of overfishing and habitat destruction owing to high fishing effort and destructive fishing techniques particularly in the coastal shallow water areas. It can therefore be anticipated that more stock depletion will occur in the future unless effective management and enforcement measures are implemented. Table 3 summarizes catches in Pemba; landings seem to fluctuate from year to year.

Table 3. Demersal fish catch from Pemba 1990-1994

Species group	1990	1991	1992	1993	1994
Rabbitfish	111,225	127,578	177,675	181,144	99,501
Parrotfish	128,970	195,524	273,846	272,635	254,436
Emperor	206,808	191,396	246,569	230,932	229,755
Grouper	61,863	54,451	78,079	73,301	60,254
Goatfish	65,360	68,708	81,398	89,398	87,486
Surgeonfish	54,766	99,172	112,698	82,358	67,991
Mullet	31,484	43,450	83,034	61,358	46,037
Mixed demersal	204,038	136,237	172,295	167,475	138,841
Shark/ray	62,435	70,653	155,123	131,360	160,175
Octopus	126,121	90,916	172,058	164,822	199,500
Lobster	58,58	12,647	31,640	16,530	19,441
Others	54,288	53,678	138,766	127,265	109,369
Total	1,107,358	1,144,410	1,723,181	1,598,578	1,472,786

Demersal marine resources

FAO studies conducted in 1995 estimated a demersal fishery potential yield of 9,950 t (Table 4), much less than the previous studies that indicated about 30,000 t (FAO 1995). It should be remembered that fishing is unlike most other extractive industries (coal or oil) because marine resources are living and self-renewing and if harvested wisely can provide continuous production. Marine fishery resources are not privately owned and therefore there is no incentive for individual fishers to husband the resources in their areas. Restraint by an individual simply makes more of the resource available to his or her competitors.

Table 4. FAO estimates of demersal fishery resources (FAO 1995)

Habitat	Group	MSY (t)	Potential Yield (kg/ha/year)
Shallow water	fin fish	2,000	13.10
	lobster	100	0.65
	octopus	250	1.60
	sea cucumber	200	1.30
	small pelagic	3,500	11.40
Deep water	fin fish	250	5.00
	squid	450	0.81
	shark/ray	1,700	0.95
Total		9,950	

This situation means that management of the fisheries cannot be left to the individual fisher. The essence of managing fisheries is to provide sustainable yield by preventing too many fish from being removed in any single year and also

to prevent fish from being caught at too young an age. It is clear that catching fish increases their death rate and so reduces the proportion of older fish in the population. It is therefore important that sufficient fish survive to maturity and be able to spawn. The optimal harvest rate and age composition in the catch varies among species. It can be influenced through such conservation measures as minimum landing size, minimum mesh size, and area or seasonal closures. Restricting the catch (quota) or the effort can protect nursery areas. It is of the utmost importance to conserve and protect the environment through restriction of destructive fishing gears and techniques.

To implement conservation measures, managers need help from scientists whose advice is rather like a ship's navigator to the captain. The scientist provides current position and course of the stock and the managers take action to achieve the management objectives.

RECOMMENDATIONS

In order for the artisanal fisheries to meet the main objectives of providing increased fish production and income for fisherfolk and other people within the industry, specific information is required of the scientists. This information should indicate the status of each fishery. It should also include the sustainable level of harvest (maximum sustainable yield) as well as identify the optimal size and age composition of the standing stock. To provide this information, it is essential that scientists, in turn, be provided with statistical information on harvest, numbers of fishers, gears types, and vessels, effort (time) and fishing location.

It is extremely important to establish marine protected areas, reserves or parks in order to preserve both marine resources and their environments and to provide for sustainable demersal fisheries. This will not only ensure high fish production but also promote tourism and hence the earning of foreign exchange.

Current enforcement and monitoring of marine exploitation is extremely weak and therefore should be strengthened by strong co-ordination among concerned parties. These include the coastal navy patrols, marine police, and the fishing communities. They should be provided with incentives that could include improved facilities and sufficient operational funding.

Beach recorders should understand the importance of collecting data and therefore be committed to their work. Officers from the fisheries head office should make frequent visits to the landing sites to see whether data recorders perform their work appropriately. Involvement of fisherfolk in the data collection is essential.

It is widely known that resource information is essential for the rational management and optimum use of any resources. In fisheries, a basic requirement is a database that covers biological, environmental, economic and social aspects of fisheries combined with the capacity and expertise to analyse the data. In Zanzibar fisheries, it is apparent that information on catch landings and fishing effort has been inadequate and unreliable. Furthermore, there are no data recorded on socio-economic and environmental issues. These data are important for devising rational plans and programmes to achieve sustainable use of the resources. Therefore it is important for the scientists and planners to seek the means to solve these problems to achieve sustainable development of the artisanal demersal fisheries.

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Status and potential of the artisanal fishery on the Tanzania mainland coast

Winfried V. Haule and Modest A. Kiwia

INTRODUCTION

The artisanal fishery of mainland Tanzania is a small-scale fishery characterised by the use of simple, passive fishing gears. The small daily catches do not require large investment in ports, cold storage, or distribution networks. Fresh fish is sold quickly and directly to the consumer or is processed using simple techniques such as sun-drying or smoking.

An artisanal fishery is often the most appropriate economic way to exploit relatively dispersed resources that are close to the shore. In practice, some artisanal fisheries can be more selective with respect to species and size composition and thus may contribute positively to the protection of the environment and maintenance of fishery resources. However, from the management point of view, artisanal fisheries are more difficult to control owing to the widely dispersed fishing areas, landing sites and the large number of fishing units. It must be stressed that artisanal fisheries exist in both developed and lesser-developed countries, as do industrial fisheries.

The mainland coast of Tanzania on the western Indian Ocean is approximately 800 km long. It covers five administrative regions, Tanga, Coast, Dar es Salaam, Lindi and Mtwara. The continental shelf is narrow and the fishery is mainly artisanal. Over 95% of the annual catch is produced by small-scale fishing, concentrated close to the shore owing to the limited range of the vessels. Fish contributes over 60% of the protein consumption of the coastal population with an estimated 2% of the population engaged in fishing. This represents about 15,000 artisanal fisherfolk operating about 3,200 fishing vessels (mostly canoes) (Table 1). They land an average of 36,700 t of fish and 700 t of prawns per year.

The status of the fish stocks is poorly known because of the lack of capability to collect the appropriate data. Fishery surveys conducted by the Norwegian research vessel R/V *Dr. Fridtjof Nansen* in 1982/83 estimated the stocks of marine fishes in waters over 20 m depth to be about 100,000 t with a potential yield of 25,000-44,000 t/year (Anon. 1983).

Table 1. Summary of artisanal fishery statistics from the territorial marine waters of Tanzania mainland for 1994 (source: Tanzanian Fisheries Statistics Bulletin, 1994)

Number of fisherfolk	15,027
Number of fishing vessels	3,232
Total catch (t)	37,286
Value of landings ('000 TSh)	11,267,325
Numbers by gear type	
gill nets	3,388
shark nets	3,427
seine nets	537
cast nets	44
scoop nets	158
ring nets	92
longlines	5,672
basket traps	5,593
fixed traps	34
"other" spears	102
Numbers by vessel type	
outrigger canoes	1,181
canoes	1,165
dhow	378
mashua	50
Number of engines	
outboard	242
inboard	64

The catch composition during these surveys was mainly sardine, Carangidae, Scombridae, ponyfish and prawns. Other studies indicated yields for the demersal fishery of 38,000 t/year, and 23,000 t/year for pelagic species (FAO 1994). These latter estimates total about 60,000 t/year in sustainable yield for the Tanzania mainland coastal waters. It is now estimated that the marine territorial waters of Tanzania have a potential yield of over 100,000 t/year (FAO 1994).

The artisanal fishery is concentrated in inshore shallow waters because of the limited range of the fishing vessels and crafts. The most productive fishing grounds are coral reefs, seagrass beds and reef flats. Sandy or muddy areas yield shark and ray. The large pelagic species include jack, swordfish, mackerel, kingfish and tuna. The groups that dominate the marine demersal catches are bream, grouper, parrotfish, snapper, rabbitfish, emperor, shark and ray. These are caught using handlines, traps and nets. The small pelagic species consist primarily of sardine, small tuna and mackerel. These are mainly caught by purse seines or ring nets. Large pelagic species such as kingfish, tuna, sailfish and marlin are caught by surface gill nets and trolling lines. Other species include octopus and lobster that are usually collected by hand from reef flats at low tide or by divers. Prawn and shrimp are caught in seines in estuarine waters,

particularly at the mouths of large rivers. Sea cucumber and cockle are gathered at low tide in the intertidal flats. Squid are mainly caught using handlines, seine nets or fixed nets.

As previously mentioned, most of the fisherfolk use simple gear and vessels with limited operational range. These vessels include dugout canoes, outrigger canoes, sailboats and dhows. These are normally driven by sails but can be fitted with outboard engines. The operational range of a vessel is determined by its size and whether it is sail or motor-driven. Vessels driven by sails rarely travel further than four km from shore. Their fishing gear includes traps, hook-and-line, nets and spears.

Two types of fish traps are used along the coast, basket and fixed stake. Basket traps were originally made of split bamboo and mangrove sticks. Many are now made of galvanised chicken-wire. They are set individually with or without bait. The traps are weighted by a pair of stones attached on the sides and marked by floats of bamboo. Under normal conditions a basket trap lasts for about three months. The high incidence of theft has forced some fisherfolk to set traps without markers and recover them by diving. Many traps are lost during fishing. The loss is higher with unmarked traps, especially during the southern monsoon. The strong currents cause the traps to drift from the point where they were set. Lost traps continue to catch fish ("ghost fish") until they disintegrate.

Seine nets are operated either on the beach or in open water near patch reefs. In the latter case, the fisherfolk survey the reefs and select the reef with the highest concentration of fish. The selected reef is first encircled with the net then the fish are scared towards the net by banging rocks on the coral heads. The fish are caught in the seine as they try to escape. This is a destructive form of fishing in that it damages reefs and catches a high proportion of immature fish.

Nylon gill nets were introduced in the late 1960s. These are long lasting and, if lost, continue fishing indefinitely. They are normally set as drift nets. The most destructive form of fishing in the area is dynamite fishing. This type of fishing has been used in the inshore waters of Tanzania since the early 1960s. It is mainly used in coastal areas near urban centres, such as Dar es Salaam, Tanga, Lindi and Mtwara. The lack of availability of affordable gear has promoted this destructive method. Dynamite fishing causes major destruction to the coral reef environment and kills fish indiscriminately. Part of the decline in the productivity of the artisanal fishery has been attributed to the use of dynamite.

Fisherfolk collect shells for ornamental purposes along the entire coast. Important groups include the queen snail, helmet snail, tiger and money cowry.

This gathering damages the intertidal and nearshore areas. They trample the seabed, break corals and overturn rocks and stones when searching for shells.

RECOMMENDATION

The most serious problem related to the artisanal fishery from the management perspective is the lack of knowledge about the size of the fish stocks. This, in turn, is caused by the lack of capability to collect the appropriate data. The only information available is based on surveys conducted many years ago. It is imperative that information on the stock status of Tanzania fisheries should be updated and improved.

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An overview of the status of the Pemba Island fishery

Anas M. Othman

INTRODUCTION

Pemba Island is 45 km northeast of Unguja Island and 60 km east of the Tanzania mainland. It lies at approximately 5° S and 39° E. The island is 62 km long and 22 km wide at its broadest point. The population is approximately 250,000 with the density of 200/km^2, about 10 times that of the Tanzania mainland. The island lies in the path of NE winds of the northern monsoon, November-March, and the SE winds of the southern monsoon, June-September. These monsoons have a significant impact on fishing activities. Mean annual air temperature is about 27° C with little annual range.

Rainfall occurs at all times of the year and averages 1,750 mm annually. The heaviest rainfall is experienced March-May and reaches peak intensity during May. These are known as the "long" rains *(masika)*. The "short" rains *(vuli)* last September-November. The hottest and driest month is February; July is the coolest month. Relatively humidity averages 80%.

Fish resources

Fish resources of special significance include the small pelagic and large pelagic species, demersal fishes, coral fishes and the lagoon and inter-tidal fishes. These are the same groups found near Unguja Island and elsewhere along the East African Coast. The small pelagic species include scad, herring, threadfin and anchovy. The large pelagic species include Indian and Spanish mackerel, bonito, yellowfin tuna, barracuda, jack mackerel and wolf herring. Demersal species include different species of shark, ray, skate, sole, catfish and shrimp. The coral fishes, which include parrotfish, emperor, goatfish and spiny lobster, are the most important group of fishes because they are easily accessible to the traditional fisherfolk. The lagoon and inter-tidal pond fishes include octopus, squid and a variety of bivalves. These are usually gathered on foot in the littoral zone by women, children and older men.

Current status

The Pemba fisheries are exclusively marine and artisanal. The artisanal fisherfolk mostly use traditional fishing vessels that cannot travel very far offshore. Thus, fisherfolk continue to fish the same grounds as their grandparents. The level of fish exploitation is not well known owing to the lack of reliable information on catch and effort. However, it is believed that fishing grounds that are accessible to fisherfolk are fully or over exploited, whereas the less accessible areas remain relatively unexploited.

There are about 12,000 fisherfolk in Pemba. Most operate with vessels; some operate on foot. The four main types of fishing vessels in Pemba are dugout canoes, outrigger canoes, boats and dhows. The dugout canoe *(mtumbwi)* is made from a single log. They lack outriggers. Propulsion is by paddles, long poles and sails. The bottom is usually flattened for stability. They vary in size. Some are large enough to carry up to 15 fishers while some can only carry one. Dugout canoes are usually used for handlining and trapping although the larger ones can be used for seining.

Outrigger canoes *(ngalawa)* are made from a single log just like dugout canoes. Outriggers *(minengo)* provide additional stability to these vessels. They are propelled by paddles, long poles and sails. They are principally used for trapping and handlining. The number of fishers varies from two to four.

Larger boats *(mashua)* are constructed out of timber planks. The stern is square and vertical to the water. *Mashua* are propelled by sails. They are usually used for gill netting, seining, trapping and handlining. The number of fishers varies from three to six. Dhows *(dau)*, like *mashua*, are made out of plank timber and propelled by sails. The bow is more pointed than the *mashua* and the stern is rounded or pointed. They are principally used for seining among coral islands. The number of fishers may vary from 11 to 16. Any of the above vessels can be modified to carry an outboard engine. Presently there are no vessels with inboard engines in Pemba.

Fishing Gear

The fishing gear of Pemba includes traps, hook-and-line, nets and harpoons. The two types of traps are basket traps and fixed stake traps. The basket traps are hexagonal in shape with a single opening. They are made of split bamboo or mangrove sticks. The larger ones are called *madema* while the smaller ones are called *towe*. Weirs *(uzio)* are semi-permanent stake traps that are set in inter-tidal areas, especially in sheltered areas.

Line fishing include handlines, bottom setlines and trolling lines; handlines are the most popular fishing line. A single handline may carry up to four hooks. Trolling lines usually use artificial lures. Bottom setlines may carry up to 20 hooks but this gear is rarely used.

The nets used in Pemba include gillnets, entangling (shark) nets, seine, cast and scoop nets. Scoop nets and purse seines use light attraction at night. Several materials are used for construction of seines. The most popular harpoons in Pemba are the spears and spear guns. These are used for catching lobster and octopus. The use of spear guns is limited.

Destructive fishing methods

Although beach seine fishing is restricted by law, the technique is still used in several areas in Pemba. Beach seines catch fish of all age groups or sizes but the smaller juveniles are discarded. Furthermore, when seines are used over sea grass beds, several plants are uprooted. When used over reefs, the corals are broken. This type of fishing can therefore cause significant depletion in fish populations as well as habitat destruction. Dynamiting is uncommon in Pemba but apparently is conducted near Matumbini Reefs and Misali Island. Law strictly prohibits this type of fishing. Apart from causing great damage to coral reefs, dynamiting kills fish of all age groups and sizes.

Herbicides, pesticides and ichthiotoxic plants were occasionally used for fishing in Pemba until recent years. Such poisons or noxious substances have the tendency to kill all life stages of the fish including the eggs as well as other aquatic organisms. Law prohibits this fishing technique.

Fisheries data collection in Pemba

Fisheries data collection in Pemba Island, as with Unguja Island, has passed through different stages. In the early 1960s, only total weight landed was recorded. This was estimated by eye in the major fish markets of Wete, Chake-Chake and Mkoani. The total estimate of fish sold in those markets was compiled and included in monthly reports.

In 1975, the Government of Zanzibar ordered that fish should be sold by weight. This was not implemented for the purpose of collection of fisheries statistics but rather to ensure that consumers could purchase fish at reasonable prices. In support of this law, 38 officers, with weighing balances, were assigned to different landing sites. The officers were supposed to weigh the catch before it was sold to the middlemen and retailers who then retailed the product by weight. The Government fixed fish prices at that time for each species. The law was successful in causing the product to be weighed. The weights of fish landed at different landing sites were summarised monthly to provide total landings for Pemba Island.

In 1984, the Government reduced the number of beach recorders from 38 to eight owing to financial constraints. The weighing balances by this time were already worn out. The remaining fish recorders were stationed only in the larger landing sites and they returned to the visual estimation procedure. In 1988, a regional FAO and South West Indian Ocean Project (S.W.I.O.P.) study dispatched fisheries experts to Zanzibar to develop a more appropriate methodology of collecting fisheries statistics. This coincided with the start of collection of data recorded to fish species or species group. From that year to the present, the information has included weight of fish recorded to species or species group,

value of the catch, number of vessels involved in fishing, and, where possible, gear used. However, because there were no weighing balances in the landing beaches, the weight of catches continued to be estimated visually.

Currently there are about 30 fisheries auxiliaries at different landing beaches in Pemba collecting fisheries information. They all have weighing balances and forms. The information is compiled in each District and then forwarded to Zanzibar for analysis.

Problems encountered in data collection

The current problems with the fisheries data collection can be itemised as follows:

- the information collected is not reliable;
- the data collected are not analysed in Pemba;
- the information on other marine products such as bivalves are not recorded;
- many of the catches are transferred at sea to buyers;
- the middlemen, especially those involved in the octopus business, do not give correct information.

RECOMMENDATIONS

To improve fisheries data collection it is recommended that:

- beach recorders and other fisheries officers should be better trained;
- more attention be directed to supervision of the beach recorders;
- the government should purchase and implement modern computer systems for storing and analysing fisheries data;
- a fisheries statistics centre should be established in Pemba;
- fisheries auxiliaries and middlemen should be made aware of the importance of fisheries statistics to the development of fisheries sector;
- statistics on all marine products should be collected and analysed.

The artisanal fishery sector in the Zanzibar economy

Mohammed F. Haji

INTRODUCTION

Narrowly defined, fishing is the business of harvesting animals and plants from the sea or inland waters. Depending on the state of development of the fishery industry, this definition can be broadened to include:

- aquaculture, the activity of cultivating aquatic animals (fish, turtles, crustaceans) and plants (seaweeds);
- fish processing, the activity of treating fish catches to improve storage qualities or improve value;
- fish marketing, the activity of selling fishery products to consumers;
- conservation of marine mammals for tourism development.

For the purpose of this seminar on the artisanal fishery in the islands of Zanzibar, the present paper concerns the whole of the marine fishery economy.

The fishery sector and the Zanzibar economy

Fishery activities have acquired a new look during recent years. There has been an expansion (re-emphasis) of seaweed farming along the coral rag beach areas and the introduction of aquaculture activities, mainly on Pemba Island. We have witnessed the introduction of the multinational corporation, the African Fishing Corporation, into fishery activities in the form of a joint venture with the former Zanzibar Fishing Company (ZAFICO). Notable also is the establishment of producer co-operatives employing both traditional and modern means of fishing. Many of these are proving to be economically viable.

Another remarkable development in this sector, is the competing need for the seashores and nearshore waters posed by tourism development. Beach areas are being used to develop hotel infrastructure while nearby waters are being used for various tourist activities including marine mammal watching. These changes are redirecting the sector away from subsistence fishing to commercial fishing (and farming) and the internationalisation of the sector. This transition is causing social conflicts and raising environmental concerns over the use of coastal and marine resources. Particular concerns include the unauthorised foreign fishing and the use of prohibited fishing techniques by Tanzanian nationals. These issues require attention, as they are a threat to the marine stocks and the economy of Zanzibar in general.

The above trends notwithstanding, a description of fishery activity in Zanzibar remains a description of the artisanal fishery. Although there are other fishing agents like the African Fishing Corporation and *Jeshi La Kujenga Uchumi* (J.K.U.: National Service Camp), it is the artisanal fishery which contributes the majority of the landings and is therefore the most important component with respect to the well being of the people of Zanzibar. Based on the provisional estimates of fish catches, it is obvious that the artisanal fishery is still the dominant fishing sector. Its contribution to the total annual fish catches is above 83.9% (1985-1996) (Department of Statistics 1996). Artisanal landings contributed 88.9% of the total landings of 24,458 t in 1996.

These statistics now include various adjustments. For example, reported domestic household consumption of fish was estimated at 21,183 t fish during 1991 (unpublished household budget survey, 1991). This was used as a surrogate for production such that landing statistics were altered to match estimated consumption. The reported exports for lobster, octopus and sea cucumber were also added to these estimates (Table 1). The current estimate of fish landings is equivalent to a monthly per capita consumption of 2.5 kg.

In spite of these adjustments, we have not been able to account for all fishery production in our estimates of GDP. Noteworthy exceptions include new developments in marine tourism, aquaculture, and the non-traditional exports. The value-added benefits from marine tourism which result from such sub-sectors as sea transport, sport fishing, eco-tourism and marine water-sports are difficult to estimate.

Seaweed is also important as an export crop and has grown dramatically in the 1990s. From 35 t prior to 1985, production has increased to 4,961 t in 1996. The growth of seaweed farming has not only offered a new (or a renewed) opportunity for the coastal people but has added new dimensions to fishery development. Seaweed farming employs many women and the increase in their earning power may have significant sociological and demographic impacts on these communities. In addition to the social impacts, the environmental impact of seaweed farming remains poorly understood.

Table 1. Exports (t) of non-traditional marine products, 1989-1995 (source: Sub Commission of Fisheries)

Product	1989	1990	1991	1992	1993	1994	1995
Sharkfin	0.5	1.0	2.2	1.5	0.2	0.6	0.3
Sea cucumber	9.0	7.3	27.4	37.3	6.1	45.4	23.0
Shark	0.8	5.4	4.2	1.9	0.2	100.0	0.5
Shells	40.2	60.0	60.5	30.0	40.0	30.0	15.0
Lobsters	8.2	7.9	4.9	11.4	3.2	150.9	0.3
Dried fish	0.5	-	-	-	-	-	-
Ornamental shell	-	0.6	-	-	-	-	-
Crabs	-	0.4	0.8	-	-	-	-
Jellyfish	-	0.8	0.6	-	-	0	-
Fresh fish	-	0.2	0.9	7.2	1.0	77.2	2.7
Seaweed	-	249.4	1308.0	2343.0	2095.8	2542.0	4287.0
Skin of grouper	-	0.1	0.1	0.3	8.4	-	-
Octopus	-	-	2.0	2.2	-	-	0.3
Fins/cucumber	-	-	1.7	1.6	-	-	-
Crab/octopus	-	-	0.1	2.2	-	-	-
Lobster/ others	-	-	0.2	-	-	-	-
Total	59.1	833.1	1413.4	2438.6	2154.9	2946.0	4329.1

The importance of the artisanal fishery is revealed by its contribution to the estimates of GDP, which range from 6.5-7.5% over the last 12 years. However, it is noted that the proportion has declined from 7.4% in 1985 to 6.6% in 1996.

Data from the Fisheries Department on the number of fisherfolk in the artisanal category indicates remarkable irregularities over the years. For example, numbers range from about 13,036 or 4.8% of the total economically active population in January 1985 to 6,445 or 2.4% in August 1985. The Frame Survey of 1989 indicated a figure of 15,550 (Hoekstra *et al.* 1990).

Another important source of statistics on the number of fisherfolk is the Population Census of 1978 (Anon. 1978). These census data indicated that for individuals in the population of age ten years and above, the number involved in agricultural occupations was 102,785, while only 2,836 (2.8%) were involved in fishing and hunting. Overall, the number of fisherfolk and hunters represented about 1.3% of the total economically active population during 1978. However, the accuracy of these figures remains questionable. A significant portion of the fisherfolk may have been reported as "mixed" farmers.

The fishery sector contributes to the general welfare of the inhabitants in the Isles, since it offers employment and income. The fishery sector also adds to the welfare of the public through providing part of their nutritional needs. Marine animals are the major source of animal protein to the Zanzibar people.

Table 2. Average price for 1/2 kg of fresh fish for the years 1985-1996 at the Zanzibar market (source: Quarterly Price Surveys: Department of Statistics)

Years	Price (TSh)	Price ($US)
1981	26.21	3.15
1982	26.48	2.78
1983	30.53	2.46
1984	36.31	2.08
1985	37.21	2.14
1986	48.77	1.72
1987	56.55	0.89
1988	78.12	0.65
1989	104.04	0.67
1990	106.79	0.55
1991	188.20	0.82
1992	247.01	0.82
1993	362.24	0.90
1994	321.19	0.62
1995	678.73	0.91
1996	728.18	1.15

The market trends also reflect the importance of the fishery sector. Data shown in Table 2, from the Consumer Price Index (CPI) of Zanzibar, indicates that the "real" price for fish has been increasing since 1981. The rising price could indicate a growing demand for fishery products owing to the growing population, possibly in conjunction with declining or stable landings. In either case, it means that demand exceeds supply. The rising price raises the concern that per capita consumption is declining with a negative impact on the nutritional health of the people.

A different impression is gained from the analysis of price in $US equivalence. For example, 0.5 kg of fresh fish in 1981 cost $US3.15. By the end of the decade (1990) the same amount cost only $US0.55. This implies that real earnings were declining for fisherfolk and fishmongers (middlemen) during the previous decade. This could account for the state of underdevelopment in the artisanal fishery since the fishers could not make sufficient savings for reinvestment. Nevertheless, a turning point may have occurred in early 1991 when real prices started rising. It remains to be seen how this has altered the welfare of the fisherfolk and or fishmongers. Note also that the prices in TSh started to increase dramatically after the turning point.

RECOMMENDATIONS

The sector requires a proper infrastructure and organisational framework for developing a reliable and consistent statistical system. These initiatives will, in

turn, require creativity, financial resources and time before the database, necessary for proper planning, can be established. The yearly baseline data should include detailed landings and price data and provide information on the structure of fishery production as well as the socio-economic condition of the fishery industry. In addition, we require the data for scientific analyses on the marine resources. These details could be provided by the Institute of Marine Science (I.M.S.), the Commission for Land and Environment (C.O.L.E.), and the Department of Fisheries.

The 1989 frame survey by the Institute of I.M.S., in collaboration with other institutions provided a valuable sampling frame for developing better data collection systems (Hoekstra *et al.* 1990). Also noteworthy was the establishment of the beach recording practice during 1997 in some selected landing sites (Jiddawi and Stanley 1999). However, we must be careful to distribute these studies over all regions of Zanzibar and not just the northern region. There also must also be better co-ordination between the efforts of I.M.S., C.O.L.E. and the Natural Resources Commission so that use of these limited research resources is optimised.

In this presentation, we have focused on the statistics about the fishery sector that are available at our department. We have commented on the problems that remain. The aim is to invite criticism so as to improve our procedures where necessary. Zanzibar's subsistence fishery cannot meet current local demand. Therefore, there is no sustainable surplus to trigger local or foreign investment interest.

Perhaps the most difficult issue is the backwardness of the fishing technology owing to the declining value of their business. To those who believe that economic growth must start from the base, they should realise that, owing to inflation and decreasing profits, the artisanal fisherfolk do not have the earnings power to modernise their fishing methods. Attention must be given to the provision of soft loans for the purchase of newer fishing gear as well as educating the artisanal fisherfolk on the importance of adapting to a new business environment. We must also provide education that will enhance their skills and improve their understanding of the importance of marine environmental conservation.

To those who think that foreign capital is the solution for the fishery sector, they must be prepared to face the possible consequences. Rapid depletion of marine resources and further marginalisation of the artisanal fishery could accompany the modernisation and increased production.

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Section II: Studies on Fisheries Data Collection

Deficiencies in the past method of Zanzibar fisheries data statistics and prospects of the proposed plan *Ali H. Kombo*

INTRODUCTION

Fishing in Zanzibar started many years ago but because of the abundant resources, few fishers and primitive gear, fisheries statistics were not considered important. However, in recent decades, the changes in fishing methods, the increase in population and the overall development of fisheries sector have led the Government to devote increasing efforts towards the collection of fisheries statistics.

In 1952, the Government of Zanzibar stationed data recorders in all the major landing sites of Unguja and Pemba Islands. The intent was to record landings and fishing effort (number of vessels and fishers). Unfortunately, even from the outset, not all the data were collected and all activities ceased after only two years.

In 1974, the Government of Zanzibar hired over 80 people and stationed them in all major landing sites of the islands. They were assigned to record landings and number boats and fishers as well as report on the needs of the fishers. These positions, however, gradually disappeared, particularly during the three-year Development Plan of Zanzibar (1978-1981) such that over half of the landing sites were left without a recorder.

From 1980-1985, the government conducted a number of frame surveys (Ngoile 1981, Carrara 1986). These studies recorded information on engines, type and number of each gear type, and numbers of fishers by gear type. These surveys indicated declining catches so a new census was undertaken in 1989 (Hoekstra *et al.* 1990) as a joint project of the Institute of Marine Sciences (University of Dar es Salaam), the Fisheries Department, the Statistics Division and the Southwest Indian Ocean Project (S.W.I.O.P.).

Drawbacks of the previous method

The artisanal fishery catch assessment system currently in use was introduced in Zanzibar in 1987 by Mr. G. Carrara (S.W.I.O.P./FAO) (Cararra 1986). There have been minor changes over the years, but the scope of the system remains the continuous monitoring of landings and effort by species group and boat type.

Seventy-six beach recorders are based at key landing sites, while the remainder of the over 300 landing sites revealed during the frame surveys are not monitored. Within the monitored landing sites, recorders collect statistics only from fishing vessels. They do not record deliveries made by fishers who fish on foot or catch retained for home consumption. Nor do they obtain information regarding the transfer of catch at sea to fish traders who market fish on the mainland. The monitoring also does not include the fishery institutions such as *Jeshi La Kujenga Uchumi* (J.K.U.) and the African Fisheries Corporation (formerly ZAFICO).

There is no set procedure regarding which or how many days to sample. Each recorder makes the selection, provided it does not fall on a weekend or public holiday. Some recorders record on weekends. Consequently, supervision is difficult since it is never known when the recorder is expected to be at the beach. Owing to the shortage of stationery, data collection forms are not provided. Recorders must record on scraps of papers that are then easily misplaced. There is no shade at most landing sites where the recorder can hang his weighing scale for the catch. Instead, the recorder must move up and down the beach following the fishers, which makes it difficult to weigh the catch. There is little effective supervision of the recorders, which leads to incomplete and inaccurate data collection. In summary, the monitoring is not conducted according to design. Data are often incomplete from the monitored sites and totally lacking for sites with no beach recorder.

RECOMMENDATIONS

In order to obtain adequate fisheries data in the same format as those of the Tanzania Mainland, the Commission of Natural Resources (Fisheries Sector) engaged the services of a Fisheries Statistic Expert technician to provide advice on how to prepare, collect, analyse and store the data. The fisheries Statistic Expert proposed the following steps (Lymo *et al.* 1997):

- conduct a new census to update the information on the number, types and ownership of boats, gear, and engines, and number of fishers;
- reduce the number of fish landing sites (Primary Sampling Units) because there are too few beach recorders and to save costs in stationery and reduce data processing time;
- base the distribution of stations on geographical divisions, with at least three in each district;
- use landings for monitored sites to estimate landings from non-monitored sites;
- assign two or three recorders for each landing site, depending on the size of landings;

- collect data for 16 days per month for the monitored sites, with a random basis for day selection, which will be provided by the person in charge of statistics and assigned through their respective District Fisheries Officer;
- use knowledge of assigned sampling days, to strengthen field supervision to ensure that data collection is improved at the source (on the beach);
- provide shade and a place to hang the weighing scale at each landing site;
- use proper data collection forms (Figures 1-6), which will be provided to each beach recorder, Fisheries District Officer, as well as the Headquarters office;
- keypunch original data and then process the data through estimation programs similar to the one used on the mainland (landings from non-monitored station will be estimated and included with the monitored station data);
- collect market and export statistics more thoroughly but do not attempt to estimate the amount of landings collected by middlemen at sea.

The proposed method will be more complete because of a better basis for including non-monitored sites and inclusion of fishers who fish on foot and landings by commercial fishery institutions.

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Date: _____ 19___ 2 -CASE 1

Type of Boat	Boat Reg No.	Type & Gear used	No. of Gear	No. of men	Species	Weight (Kgs)	Value (Shs.)	No. of Fish	Depart. Time	Fishing time	Arrival time	Remarks	Super-visor

Figure 1 Daily landings record

REVOLUTIONARY GOVERNMENT OF ZANZIBAR

2-CASF 2

MINISTRY OF AGRICULTURE, LIVESTOCK AND NATURAL RESOURCES

FISHERIES SECTOR

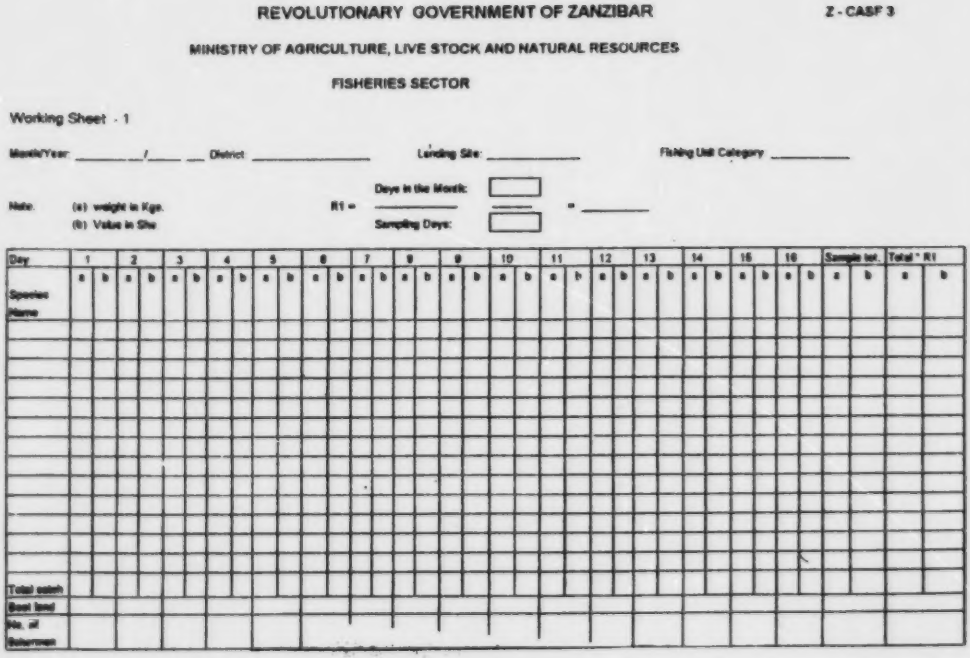
DAILY RECORD OF FISH LANDED

District: ..... Landing site: .....

Month: ..... Fishing unit category: .....

Note: (a) Weight of fish in Kilograms
(b) Value in Shs.
(c) No. of fish

1	2	3	4	5	6	7	8	9						10						11						12				13	
Date	Type of Boat	Reg. no.	Type & No. gear	No. of fishers	Days/Hours	Duration for fishing	SPECIES																						Total		
							a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c



REVOLUTIONARY GOVERNMENT OF ZANZIBAR

Z - CASF 3

MINISTRY OF AGRICULTURE, LIVE STOCK AND NATURAL RESOURCES

FISHERIES SECTOR

Working Sheet - 1

Month/Year: _____/____ __ District _____ Landing Site: _____ Fishing Unit Category _____

Note: (a) weight in Kgs. (b) Value in Shs

Days in the Month: ____ R1 = _____ = _____

Sampling Days: ____

Day	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		Sample tot.		Total * R1	
Species /Name	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
Total catch																																		
Boat land																																		
No. of fishermen																																		

Figure 3 Monthly record of landings

REVOLUTIONARY GOVERNMENT OF ZANZIBAR Z - CASF 4

MINISTRY OF AGRICULTURE, LIVE STOCK AND NATURAL RESOURCES

FISHERIES SECTOR

Month/Year _____ _____ District: _____ Fishing Unit category: _____

Working Sheet - 2

Note: (a) Wt. in M. Tons
(b) Value in 000's Shs.

R2 = No. of Fishing Units in the District: ☐ / No. of Fishing Units in Sampled Landing Sites: ☐ = _____

Name of landing site															Total wt. and Value		Total * R2	
Name of Species	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
Total catch																		
Boat landed																		
No. of Fish. men land.																		

Figure 4 Monthly total of landings

Figure 5 Monthly landings by vessel

REVOLUTIONARY GOVERNMENT OF ZANZIBAR

Z -CASF 5

MINISTRY OF AGRICULTURE, LIVESTOCK AND NATURAL RESOURCES

FISHERIES SECTOR

Month/ Year: _____ _____

District: _____

Total Estimated Catch and Value of all Fishing Categories by Species

Note: (a) Weight in M Tons
(b) Value in 000's Shs

Fishing Unit Category	Ngalawa		Mashua		Dau		Mtumbwi		Boat		Foot Fishermen		Total Est Catch in M Tons	Total Value in 000's Shs
Name of Species	a	b	a	b	a	b	a	b	a	b	a	b		
Total Catch														
Total No of Vessels														
Total No. of Fishm														

NB Total number of Vessels and Fishermen as obtained from the Census Survey

REVOLUTIONARY GOVERNMENT OF ZANZIBAR Z - CASF 6

MINISTRY OF AGRICULTURE, LIVE STOCK AND NATURAL RESOURCES

FISHERIES SECTOR

Month/ Year _____ _____ District _____ Fishing Unit category _____

(Calculation of mean catch per boat, mean crew and mean catch per man)

Name of landing site									Total
Total sample catch									
Total no. of Boats sampled									
Total no of Fishermen									

Average Catch per Boat Landing	
Average No. of Fishermen per Boat	
Average Catch per man per Trip	

Note The above totals refer to the sampled fishing units only

Figure 6 Monthly summary

Artisanal fisheries of southern Tanzania, data collection methods, status of fisheries and resource use management

Martin Guard

INTRODUCTION

Coastal and marine habitats of southern Tanzania support an abundant and diverse array of marine resources. These fish and invertebrates represent an important source of income and protein for coastal fisherfolk and inland rural communities. The exploitation of these resources is primarily undertaken through small-scale artisanal practices such as the use of shark nets, beach seines and fish traps. Just 2% of the total Tanzanian fishery yield is produced by "Industrial" fisheries. With the steady growth in population, the demand for marine resources is further increasing. The problems of over-exploitation as well as the degradation of coastal and marine habitats through the use of destructive fishing practices are now evident.

The Frontier-Tanzanian Marine Research Programme, a collaboration between the University of Dar es Salaam and the UK-based Society for Environmental Exploitation, has conducted studies on the levels and patterns of artisanal resource use since 1989. The purpose of the program is to understand the impacts of such practices on fish stocks and provide a clearer picture of the status of individual fisheries in southern Tanzania. These studies have concentrated on three locations: Mafia Island (1989-1995), the Songo-Songo Archipelago (1995-1996), and Mnazi Bay, Mtwara (ongoing) (Map 1 and Table 1).

The present paper provides a summary of the methods and results of this programme and a brief discussion of the development of community-based resource management in the Kilwa, Lindi and Mtwara districts (see Horrill and Ngoile 1991, Darwall 1996a-c, and Guard 1997 for more detailed accounts of each fishery).

Data collection methods

Frontier-Tanzania utilises self-funded volunteers to collect data as they accompany local fishers to their fishing sites. With an average of 16 research assistants through the survey period, the project was able to compile extensive data sets of fisheries catches from actual fishing sites rather than landing sites. Monitoring at landing sites often misses the portions of the catch, which have already been discarded (turtles), processed, or sold prior to arrival. Accompanying fisherman on their fishing trips also permits observation on habitat destruction associated with the technique. These data can also then be

summarised to provide estimates of catch, species composition and catch-per-unit-effort (CPUE) for each fishery and location. Prior to these studies, only government fishery statistics were available for this task and in many areas these were considered unreliable. In some cases, it was obvious that the same values were simply re-copied in consecutive years.

Table 1. Characteristics of the survey areas

Mafia Island	Officially proclaimed a park in 1995. First multi-user marine park in Tanzania. Highly productive area covering approximately 300km^2. Consists of 33 km of outer reef, four small islands and numerous patch reefs.
Songo-Songo Archipelago	Small archipelago south of Mafia Island. Contains five islands and over 35 patch reefs. With the creation of Mafia Island Marine Park, fishing pressures here were expected to increase. Visited by fishers from as far away as Zanzibar and Mtwara.
Mnazi Bay, Mtwara	Area of coast located from just north of the Mozambique border to Mtwara harbour. Makonde fishers move up and down the coast from Mtwara to Machinga, Kilwa and the Songo-Songo archipelago, depending on the time of year. The coastline is highly exposed so fishing activity is restricted to inside the outer reef except during good weather.

Working in pairs, volunteers collected the following information on fisheries catches using prepared forms:

- type of fishery;
- number of fishers;
- boat and gear type;
- departure and arrival time at the landing site;
- arrival and departure time at the fishing site;
- location of the fishing site;
- time taken to retrieve and deploy the nets/lines/traps;
- length of time the gear was fishing;
- species or family composition of the catch;
- length of all fish caught;
- length and mesh size of nets;
- number and size of hooks.

In cases where the catch was large or time was limited, the information collected was prioritised as follows:

1. total weight and number of catch (CPUE);
2. species or family composition of the catch;

3. smallest and largest fish in the catch;
4. number of each species caught;
5. mean size (length and weight) of each species;
6. length frequency distribution for each species, starting with the most abundant species in the catch.

Additional information that was collected included:

- fecundity of shark and ray species;
- sex ratio of shark and ray (these species can be sexed externally through the presence or absence of the male's claspers or modified pelvic fins).

Comparative catch statistics

A summary list of catches for the three locations is provided in Table 2. The project included an examination of the artisanal fishing gear, including shark net *(jarife)*, seine net *(juya)*, handline *(mshipi)*, fish trap *(dema)*, fence trap *(wando, uzio)*, and octopus and sea cucumber gathering.

Shark nets

The shark net *(jarife)* is one of the most important gear types in Tanzania. The shark fins are dried and shipped to oriental markets. The large mesh entanglement net is primarily set on bottom, but in the Mtwara district, a drifting gillnet is also used. The main target species are shark and ray in the bottom sets with large pelagic species such as marlin, billfish and tuna targeted in the drifting net. Estimated total landings for the Songo-Songo archipelago were 170 t per year. Catches averaged 82 kg/trip. The Songo-Songo catches are approximately eight times larger than those at Mafia Island and Mtwara. The difference is caused by the large catch of stingrays (Dasyatidae). Stingray catches previously dominated in Mafia Island but the proportion has dropped dramatically from 70% in 1991 to just 8% in 1993, during the study period. The majority of the bottom gillnet catches at Mafia Island now consist primarily of large grunt and emperor with shark and ray only representing 20-30% of the catch by weight.

The large reduction in catch of stingray at Mafia Island is probably a result of fishing pressure. The complex life history characteristics of ray and shark make them especially vulnerable to over-fishing. In particular, their low fecundity implies that recruitment is minimal each year. Since the project ended in Songo-Songo, fishers have also reported that catches of ray have declined dramatically and that this represents a major threat to their fishery. The lower CPUE at Mafia Island and declining catches at Songo-Songo indicate that measures are urgently needed to regulate this fishery.

Another concern associated with gillnets is the high incidental capture of turtles.

Thirty turtles were caught in the 76 sampled fishing trips in the Songo-Songo archipelago. This figure, extrapolated to an annual estimate, represents 810 turtles. This estimate, when added to annual catches of 400 turtles per year at Mafia Island (Darwall 1996a) and 300-400 at Mtwara (Guard 1998), represents significant mortality to this endangered animal group. This bycatch obviously needs to be addressed. If these fishers were to switch to longlines, it would reduce the turtle bycatch, but the switch may encounter significant resistance since this fishery produces significant landings of large shark and grouper.

Seine net

The seine net fishery is another important gear type of southern Tanzania. It is used by many of the fishing co-operatives especially at Songo-Songo and adjacent to Mnazi Bay, Mtwara. Seine nets can be split into two main types, boat seines *(nyavu kokoro)* which have a 6 cm mesh, and beach seines *(juya)* which have a 1-3 cm mesh. Seine nets can be operated as purse seines *(kavogo)* when the lower line of the seine is drawn in to seal off the bottom of the net.

The average catch per seine trip reported herein are for beach seine only (Table 2). Catch rates were similar for Mafia Island and Songo-Songo but markedly lower in Mtwara. The largest total yield was obtained from Mafia Island (386 t). Mafia Island nets tend to be shorter than the other two areas. We observed differences in the catch compositions between the three areas. In particular, Mtwara catches contained a large proportion of rabbitfish.

Catch rates (kg/trip) at Songo-Songo and Mafia Island were higher than those reported for other regions of the Indian Ocean (Table 3) such as Madagascar Island and Kenya, which are thought to be overfished. Although some variation would be expected among areas, it may be assumed that the southern Tanzania fisheries are not subject to the same level of exploitation. There is, however, a danger in basing evaluation on total yields. The possibility of localised over-fishing must still be considered.

Table 3. CPUE (kg/trip) for similar fisheries in the Indian Ocean

Place	Years	CPUE (kg/trip)	Reference
Mtwara	1996-1997	58	Guard 1998
Songo-Songo	1995-1996	84	Darwall 1996c
Mafia Island	1993	88	Darwall 1996b
Madagascar	1989-1990	17	Laroche and Ramananarivo 1995
Seychelles	1986	89	Laroche and Ramananarivo 1995
Mauritius	1986	15	Laroche and Ramananarivo 1995
Kenya	1984	33	Laroche and Ramananarivo 1995

Table 2. Summary of catch statistics for Mafia Island (MI), Songo-Songo Archipelago (SS) and Mtwara (Mt)

Gear	Area	Catch (t/year)	Av. Catch (kg/trip or trap)	Fishing Effort	Av. Income (TSh/person/day)	Catch Composition by Weight (%)
Gillnet	MI	36	11	8,600 m net laid/day	1,000	ray (40), shark (12), grouper (5), other (43)
	SS	170	82	14,100 m net laid/day	1,500-2,500	stingray (65), eagleray (21), shark (5), other (9)
	Mt	15	17	6,000m net laid/day	2,000	shark, marlin, billfish, ray
Seines	MI	386	88	6,200m net laid/day	1,500-2,000	emperor (28), surgeonfish (17), parrot (11), snapper (10), rabbitfish (9), triggerfish (6), other (19)
	SS	150	84	8,600m net laid/day	1-2,000	parrotfish (20), goatfish (19), emperor (19), rabbitfish (17), other (25)
	Mt	90	58	4,000m net laid/day	1,000	squirrelfish (15), surgeonfish (4) rabbitfish (43), damselfish (11), parrotfish (9), triggerfish (9), snapper (6), other (3)
Handline	SS	200	N/A		3-6,000	emperors/snapper, grouper/jack
	Mt	210	7		1-7,000	pelagics
Dema trap	SS	31	0.85	>150 traps	3,500	parrotfish (25), surgeonfish (17), emperor (16), snapper (9), rabbitfish (9), other (24)
	Mt	93	4.6	>100 traps	8,000-10,000	rabbitfish (63), wrasse (14), goatfish, (5), other (18)
	Zanz	2.23	0.195			goatfish (21), snappers (15), other (64)
Fence trap	Mt	≈86	12kg-7.5t	2 traps	9,000-1.5 million	tuna (90), mullet (4), jacks (2), halfbeaks (1), other (3)
Octopus gath.	MI	74	5.0	>200	1,500-8,000	N/A
	SS	62	4.23	>150	1,500-10,000	Dominant size classes 51-60, 61-70
	Mt	75	7.3	>150	3,000-8,000	Dominant size classes 41-50, 51-60
Sea-cucumber gath.	MI		3.7 pieces		2,000-10,000	
	SS	7	8 pieces		4,000 - 35,000	
	Mt	Fished out	N/A		N/A	

Problems associated with seine are the snagging of nets on coral heads, trampling of corals by fishers and the use of small mesh sizes, which catch undersized reef fish.

Handline

The handline fishery is probably the most important in terms of total yield and number of fishers involved. Several methods of handline fishing are practised and range between small gauge lines with hooks mounted on separate leaders to heavier gauge lines with lures that are trolled behind a boat under sail. It was not possible to accompany these gears to the fishing grounds to collect catch records as the majority of boats used were small dugouts (*mtumbwi* and *ngalawa*) with too little space for observers. All records were therefore collected from landing sites. Fishers claim that their daily catches are worth TSh3,000-6,000. There do not appear to be any particular concerns with this fishery except that owing to the increasing number of visiting fishers using handlines, monitoring of catches should be continued.

***Dema* Traps**

The *dema* trap fishery supports approximately 100-150 fishers in southern Tanzania. Catches are reported to be highest during the northern monsoon when the winds are weaker. In Mtwara, catch per trap is nearly six times greater (4.6kg) than Songo-Songo (0.85kg) and more than 20 times the catch rates reported from Zanzibar (Flora Mgimwa, pers. comm.). The composition of the catch in Mtwara is mostly rabbitfish, while elsewhere small parrotfish, surgeonfish and emperor dominate. The two main concerns with this fishery are the capture of small reef fish and the continued "ghost fishing" of lost or abandoned traps.

Traps

Fence traps were surveyed only in Mtwara. Although catches were highly variable and number of days fished dependant on tides, the income gained from the occasional large catches of jack and tuna *(Euthynnus affinis)* indicated that this kind of fishing could be very lucrative. The largest catch for 1 day was 5,000 small tuna with a total weight of 7.5 t and a value of TSh1.5 million.

Octopus

During spring tides, many people collect octopus in the intertidal areas using spears and sticks. Catch rates per individual ranged from 4.2 kg at Songo-Songo to 7.3 kg at Mtwara. At Mtwara, the majority of octopus is salted and dried and sold for local consumption or sold to dealers who re-sell inland. Due to the availability of ice at Mafia Island and Kilwa Masoko, south of Songo-Songo, the majority of octopus landed at these sites is sold fresh to dealers who then transport it on ice to Dar es Salaam markets. Fresh octopus returns a higher price

than dried octopus and the more experienced snorkel fishers can earn up to TSh10,000/day. In contrast with some places in Zanzibar and Pemba, where local communities implement a closure during spawning seasons (May-July), octopus are fished year round in southern Tanzania. The octopus fishery at Mafia Island was shown to decline rapidly following the arrival of commercial buyers who offered higher prices (Horrill and Ngoile 1991). With high prices now being offered at Songo-Songo, the fishery is liable to follow the same pattern. Regulation and monitoring is urgently required in order to detect early signs of overfishing. Size declines have already been reported but further work is needed.

Sea cucumber

This sea cucumber fishery is one of the most lucrative in southern Tanzania. It is fished by SCUBA, free-diving and gleaning in the intertidal zone. Although 15 principal species are collected, nearly 50% of the catch from Songo-Songo was dominated by one species called *ulimbo*. The fishery on Songo-Songo is estimated to produce 7 t per year. Catch per trip averaged from three to four pieces collected at Mafia Island to an average of eight pieces collected at Songo-Songo. Average income is approximately TSh4,000/day, although up to TSh35,000/day has been observed. The sea cucumber resource of Mtwara is reported to be seriously overfished (Guard 1998). However, in Msimbati town, up to 20 t of sea cucumber, collected from northern Mozambique, has been traded in a single month. The sea cucumber is sold in Tanzania because of the more established markets and better prices.

Blastfishing

The greatest threat to coral reef areas and the associated fisheries in southern Tanzania is probably blastfishing. Blastfishing is conducted in all shallow water habitats from Songo-Songo to the Mozambique border. Only at Mafia Island has it been reduced through the use of a high speed patrol boat to police the park.

In the Kilwa district, including Songo-Songo to the south, this practice is conducted mainly by fishers from Dar es Salaam. Under the guise of ice packer boats, they both buy fish from other vessels and catch fish themselves with blastfishing. Their ice chests are reputed to be filled half with dynamited fish while the other half is filled with fish purchased from local fishers. The situation is complicated for local fishers because although they voice their disdain for this practice they depend on these buyers for regular income and are therefore reluctant to take action.

The situation is different in Mtwara and Lindi districts. Local youths there buy the dynamite from local dealers and fish with the explosives from canoes. The dealers obtain the dynamite from road, mining, and quarry projects. Locals are aware of the consequences of this destructive practice but are reluctant to take

action because of the history of inaction by legal authorities and leniency of sentences in all three districts. A total of 440 blasts were recorded over a 60-day period in Mnazi Bay. Over 40 blasts were recorded in a single day at Mpovi reef, Kilwa Kivinje (Guard 1998).

Underwater visual census for estimating commercial fish abundance

Underwater visual census (UVC) surveys of numbers and biomass of target fish groups can be useful for assessing fisheries. There are a wide variety of methods with most designed to provide estimates of size and abundance at both family or species level.

Table 4 lists the abundance of target fish groups by reef sites in relation to a standard period of time. These UVC estimates represent the numbers of fish observed per hour of survey. Observers swim for 30 minutes along specific 5 m transects. These methods are useful for identifying those reefs of high target fish abundance or for identifying which target fish groups dominate. Additional information can also be gathered on fish size by estimating fish lengths. Fish lengths are transformed into weight estimates using length/weight relationships. The weight estimates can then be converted to biomass for each size class of each fish group in each reef. These data indicate where the important fish stocks are located, their size range, and provide an indices of abundance. This information on fish community structure can be combined with fishery catch composition to provide guidance on which gear type will optimise harvesting. Another important but often ignored component of UVC fish surveys is their ability to identify

	Msimbati Outer Reef	Ruvula Reef	Chambo Cha Chumba	Mnazi Bay South	Ras Msimbati	Chambo Cha Kati	Island Complex
S/e/g	23	91	48	9	61	**140**	39
Parrotfish	20	35	**46**	8	43	29	20
Jack	<1	13	0	0	1	<1	**17**
Grouper	2	2	**4**	0	3	**4**	3
Triggerfish	7	10	6	0	2	2	**17**
Surgeonfish	71	**111**	78	10	54	36	63
Fusilier	144	436	180	75	35	738	44
Barracuda	<1	19	0	0	<1	**1**	10
Ray	<1	0	0	0	**10**	0	0
Shark	**<1**	0	0	0	0	0	0
Moray	0	0	0	0	<1	**1**	0
Total no.	271	717	362	102	211	**952**	213
Less fusiliers	127	**279**	182	27	176	214	169

Table 4. Estimates of fish observed per hour for each commercial fish group at each reef site. Shaded areas represent the location of highest abundance for each fish group ("s/e/g" refers to snapper, emperor and grouper).

fishing effects by highlighting any shifts in the fish community structure over time. Previous studies have shown that even low fishing effort can cause significant changes in community structure (Polunin and Roberts 1993, Watson and Ormond 1994, Jennings and Polunin 1996). A greater understanding of these changes combined with improved fisheries data collection can lead to improved fisheries management initiatives and regulation.

The development of community based coastal zone management in the Kilwa, Lindi and Mtwara districts.

Marine environmental studies and community based development initiatives have a long history in the Kilwa, Lindi and Mtwara districts (Table 5). Over the past three years, marine environmental management in these districts has developed within the framework of the Marine Environmental Protection Programme (M.E.P.P.). Facilitated by the Rural Integrated Project Support Programme (R.I.P.S.), the M.E.P.P. was initiated in 1994 following a workshop in Sudi Town. Villagers, local government officers and the police met to discuss problems relating to the marine environment. By providing a platform for "knowledge swapping" as well as debate and decision making on marine environmental issues, the M.E.P.P. intends to foster community organization and empower (assisted by local government) local people to manage and accept responsibility for their local coastal and marine resources. The first step towards this goal was the collaborative formulation and implementation of several initiatives. The initiatives included:

- the formation of the Sudi Committee;
- the introduction of seaweed farming;
- a revolving village credit scheme to enable fishers to purchase conventional fishing gear;
- the construction of a fresh fish market in Kilwa Kivinje;
- blastfishing patrols;
- the production of media material such as community videos and radio programmes through which local communities can express their views.

The success of these initiatives was later assessed at a workshop in Msimbati Town in 1996. Although most initiatives (except dynamite patrols) had positive results and represented committed local government and village action, further discussions revealed that more information was required on the status of the coastal and marine habitats and the levels and patterns of resource use in the region. This information is now being collected by the Frontier-Tanzania Marine Research Programme which, in collaboration with the M.E.P.P., is conducting a two year programme of surveys.

As this information becomes available, further workshops and group discussions are planned. From these meetings, three pilot management areas within the three

districts will be selected (one already) and management objectives such as the introduction of a voluntary fishery logbook scheme will be implemented. Restricted fishing and gear use areas (zoning schemes) are also planned. In addition, training in simple marine survey techniques, collection of fisheries data, basic data analysis and communication techniques will be provided to fisheries officers and elected community representatives. This training will provide a core of local expertise able to train other villagers to join the present programme of marine and resource use surveys and conduct future marine environmental monitoring.

Local community representatives recently wrote a constitution to formally register their own community's environmental NGO (The Southern Zone Confederation for the Conservation of the Marine Environment). Through this organisation, they can formally express their opinions and needs. It is clear that the M.E.P.P. is moving forward and providing new optimism in the communities.

However, while there is a basis for optimism, many problems remain. More focus is required on the needs of local youth and women and more commitment is needed by all parties to bring about a cessation in blastfishing, which is the single biggest threat to the marine environment in the region. Nevertheless, through a continuing policy of listening and learning which involves all stakeholders, these problems are slowly being addressed and with further commitment in the communities, collaborative management of the marine environment has a chance of lasting long into the future.

RECOMMENDATIONS

We strongly suggest that the following be considered:

- collection of the detailed baseline data that are essential to monitor resource status using standardised techniques;
- implementation of a simple voluntary logbook scheme by local fishers supplemented by small-scale intensive sampling by trained personnel;
- use of UVC surveys especially for indicating effectiveness of fishing gears and revealing fishing effects on fish community structure;
- use of participatory workshops and facilitators trained in Participatory Rural Appraisal techniques in order to better understand local user perceptions in relation to fishery problems and their possible solutions;
- recognition that no one management approach will suit all areas and that a flexible integrated approach involving a variety of disciplines will provide the best results;
- development of effective communication links between relevant institutions to reduce duplication of effort and enable more effective use of limited resources.

Table 5: Summary of Coastal and Marine Management in Southern Tanzania

When	Where	Who	Objective	Results
1979	Mtwara	Dept. of Education and Fish. and local fishers	To train local fishers in seining, light fishing and drift netting techniques	First fishing co-operative formed. (These are still operating)
1989	Kilwa, Lindi and Mtwara	UNEP Action Plan	Marine reserves and multiple use management areas proposed for Songo-Songo, Machinga Bay to Ras Banura, and from Msamgamku to the Ruvuma Delta.	No sites were gazetted
1994	Sudi	R.I.P.S., local resource users, local government and the police	To discuss marine environmental issues and formulate action for the protection of the marine environment	• Formation of Sudi and other village committees • Signing Sudi declaration • Dynamite patrols • Credit scheme • Workshop video • Construct Kilwa market
1994-96	Songo-Songo and Kilwa	Frontier-Tanzania	Collection of biological and marine resource use data for the region	Series of habitat maps and reports assessing the regions' bio-status, levels and patterns of marine resource use, and associated problems
1996-97	Mtwara	Frontier - Tanzania	Begin biological and marine resource use surveys in Mtwara	Preliminary findings highlight localized overfishing and damage from blastfishing
1997	Mtwara, Lindi and Kilwa	RIPS and Frontier-Tanzania collaboration	• Extend surveys from Mtwara to Kilwa Masoko to 24 months • Train local community representatives and fishery officers • Introduce voluntary logbooks • Facilitate community workshops at three pilot areas • Assist in formulation of community based management initiatives • Establish monitoring programme for each pilot area • Develop data base system	• A series of community workshops • NGO status for the Sudi Committee • Representatives from the Sudi committee meet the Prime Minister and other Ministers.

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A study of the artisanal fishery in the villages of Matemwe and Mkokotoni, Zanzibar, Tanzania

Narriman S. Jiddawi and Richard D. Stanley

INTRODUCTION

Artisanal fishing methods in the state of Zanzibar, Tanzania produce an estimated 14,000 t per year (FAO 1994). These fisheries provide income to about 16,000 artisanal fishermen, an equal number of fisherwomen and approximately 2,500 fish traders. This represents about 14% of the population. These fisheries provide the most common source of dietary protein in Tanzania and, almost the only animal protein consumed by the lowest income group (FAO 1994). In addition to employment and nutrition, the fisheries are assuming an even higher profile owing to the rapid expansion of tourism.

The importance of these fisheries has created an urgent need for resource assessment information in Zanzibar. However, our preliminary examination of landings in small fishing villages revealed that the existing monitoring system, while suitable for providing general information, did not provide the accuracy and detail needed for stock assessment. In particular, current data collection could not capture even the most blatant changes in catch rate, mean size, or species composition.

To demonstrate the value of accurate landings data and explore the practicability of its collection, we initiated a study of the landings of two villages in northern Unguja Island. The study was conducted by the Fisheries Stock Assessment Project of the Institute of Marine Sciences (I.M.S.) of the University of Dar es Salaam (U.D.S.M.) and the Canadian International Development Agency (C.I.D.A.) with assistance of the Sub Commission of Fisheries (S.C.F.) Our objectives were to:

- develop a working research relationship between the S.C.F. and I.M.S.;
- develop a positive working relationship with the fishing community in the two villages;
- examine the manpower, resources, and time required for direct estimation of landings at a landing site;
- identify and quantify the sources of variance in estimating daily landings;
- obtain statistically defensible estimates of annual landings for both villages;
- examine the fish composition in the landings by each gear type;
- provide baseline information on species diversity and catch rates;
- provide a test data set that could be used for improving designs for future studies.

This report provides a brief summary of methods and results of this study.

Study site

The two landing sites were in the villages of Matemwe and Mkokotoni, located on the northwest and northeast corners respectively of Unguja Island (Map 1). The constituency of Matemwe on the northwest coast includes the small villages of Muyuni, Kigomani (the auction site), Matemwe and Kilima Juu, each with a few hundred inhabitants. The geology of the east coast of Unguja is exposed coral rag. Farming is limited and the principal vocation for men is fishing. Many women have recently begun to farm algae. The east coast is dominated by a unbroken fringing reef, 0.2-0.7 km from the shoreline. The maximum depth of the reef flats at high tide is approximately 6 m. The intervening reef flat is mostly exposed during low tides.

The Mkokotoni auction site is located in the town of Mkokotoni on the west coast of Unguja Island at the head of a large bay. Tumbatu Island lies to the west. Fishers from surrounding villages, including Tumbatu Island, deliver fish to this auction. Most of the product is delivered directly by boat. There are patches of coral reefs within their fishing area, but no unbroken fringing reef as found on the east coast. There is also a large sandy tidal area nearby with fringing mangrove forests.

All participants in the fishery are Muslim. The local fishers usually land their product close to home, but they also report that for 1-2 months per year they leave their villages to fish elsewhere on Unguja and Pemba Islands, or even range as far as the coasts of Mozambique and Kenya. They refer to these journeys as *dago* trips. Fishers report that they make these trips to take advantage of better seasonal weather conditions or more productive grounds. These trips also represent an opportunity to save money. While local fishers dominate landings in Matemwe and Mkokotoni, *dago* fishers from elsewhere sometimes land significant quantities to these sites.

Most of the fish is sold locally, distributed to nearby villages by bicycle and consumed that evening. The lack of power in surrounding communities precludes overnight storage unless the fish is smoked, salted, or cooked. Fishers prefer to unload and sell the fish early enough in the afternoon to facilitate distribution. Some of the production and most of the highly priced products (lobster, crab, marlin, sailfish) is transported to Zanzibar city. Fishers reported during interviews that they retained all species of fish that they caught with the exception of a "small black ray" that was considered bad luck, and possibly poisonous, to eat. As commented by Munro (1996), there is no such thing as "trash" fish in developing countries.

Oceanography and climate

The NE winds of the northern monsoon and SE winds of the southern monsoon dominate the climatic and surface oceanographic conditions of Zanzibar (McClanahan 1988). Cooler temperatures, stronger winds and more rain, characterise the southern monsoon (June-September). Water temperatures are cooler because of lower air temperatures and greater surface mixing. During this period some fishers move their activities from the east to the west coast. Conditions reverse for the northern monsoon (November-March), although winds can be strong in January. The major rainy period occurs during the transition between northern to southern monsoons (April-May) with a less intense rainy season during the second transition (October).

Zanzibar waters undergo a semi-diurnal tidal alternation with succeeding high tides slightly over 12 hours apart and the associated "spring" to "neap" tide variation. The tidal range during spring tides frequently exceeds 450 cm. There is a lag of 1-3 days after the new or full moon for the peak of the spring tides (Fig. 1). Fishers refer to the fishing periods in number of days since the new moon. For example, the fishing days of the spring tides may be referred to as days 25-5 and 10-18 of the lunar cycle or *bamvua kubwa* ("large fortnight").

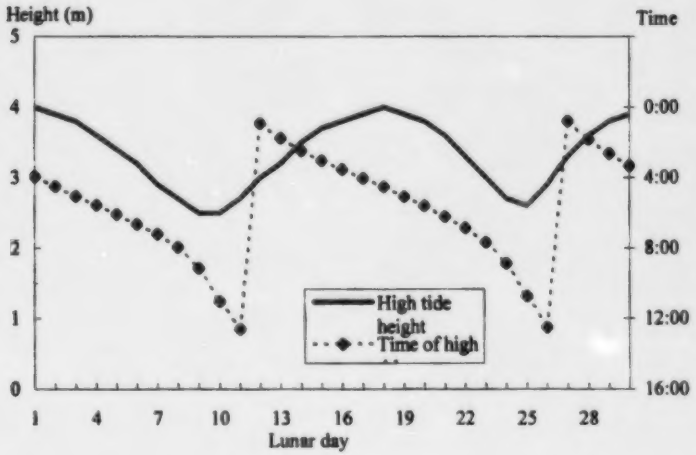

Figure 1. Height and timing of morning high tide in Zanzibar (March 1997)

The timing of the high tides over the lunar cycle is stable within the year such that the morning high tide on the day of the new moon occurs about 0430 h plus or minus 30 minutes throughout the year. Depending on which day one chooses

within the lunar cycle to designate the start of the spring tides, they peak from about 0200-0700 and 1400-1900 hrs, while the diel neap tides peak nearer to mid-day and midnight (Fig. 1). We used tide times and fluctuation for Zanzibar town as the reference station (06.09S, 039.11E), courtesy of the University of Hawaii [1].

The diurnal fishery

The typical fishing day for the daytime fishers in Matemwe begins near dawn by using the early morning high tide to clear the fringing reef. They fish from shortly after dawn until about noon, when they begin their return, clearing the reef again on the afternoon rising tide. Most of the vessels cross the reef at one of three low points a few km north of the auction site. They then sail (during the northern monsoon), or pole and paddle southwards (during the southern monsoon) along the shoreline. As they reach the auction site, 1-2 fishers disembark with the catch, while the remainder of the crew continues southwards along the beachfront for up to 1 km where they anchor near their homes.

The crew members carry their catch up the beach by stringing small and medium sized fish on a rope strand *(mtungo)*. Large quantities of small fish are sometimes delivered in sacks. Large fish are carried by hand. The landings are laid in the sand in order of arrival until being auctioned. Some of the larger fish are scaled and butchered immediately after the auction. Young boys process the octopus by pounding it with a long stick to make it more tender.

There is a separate nocturnal fishery in Matemwe that uses large motorised vessels to fish with gillnets north of Unguja Island. This fishery is organized as a cooperative and summarized by Richmond (1999). During interviews with fishers, they reported that a small number of the *ngalawa* fishers switched to nocturnal fishing moonless nights of the southern monsoon. They unloaded their catch at dawn to one buyer. These landings were not examined in the present study, but were reported to be quite small in comparison with landings from diurnal fishers.

The daily fishing pattern was similar in Mkokotoni, but the lack of the fringing reef provides flexibility in leaving time. As with Matemwe, we were informed that nocturnal fishers using handlines provided a small amount of landings early in the morning prior to the arrival of our samplers. We occasionally observed a few large pelagic species (tuna or shark) in the market as the samplers arrived in the morning.

Gear Types

The dominant gear types were typical of reef and near-reef fisheries (Ruddle

[1]UH Sea Level Center, University of Hawaii, 1000 Pope Road, MSB 430, Honolulu, Hawaii, 96822, USA

1996a). They include portable traps, small seines, drive-net fishing, spearfishing without scuba, and handlining. Most of the octopus is collected using a hooked stick by fishers walking on or near the reef crest. Some octopus is collected free-diving. Small quantities of mangrove crabs are captured with a weir near Mkokotoni.

Some production from diurnal fishing did not pass through the auction. This included lobster, destined for the restaurant trade, and sea cucumber destined for foreign export. We did not attempt to estimate the portion of the catches retained for home consumption. It appeared to be less than 5% for most fishing as we rarely saw significant amounts carried to the homes. A possible exception was the fishery with large seines. Each member of the crew, which sometimes exceeded 40 men and boys, were often observed to retain about 1-2 kg of the lower valued small fish that this gear usually captured. Nor did we did try to estimate the landings produced by intertidal gleaning of small fish and invertebrates by women and children.

Vessels and fishing grounds

Most fishers travel to their grounds in crews of two to four aboard double-outrigger dugout canoes (*ngalawa*), or with larger crews aboard larger plank-built boats (*dau, mashua* or *boti*). Seine net trips were usually conducted from dhow, *mashua* and *boti* vessels with large crews. Double-outrigger deliveries dominated in Matemwe, while dhow landings dominated in Mkokotoni.

Since most of the vessels were non-motorised and making day drips only, fishing grounds were no more than four hours sailing time away and usually less than two hours. In Matemwe, most fishing took place on or outside the fringing reef or around the reef of the nearby Mnemba atoll, about 6 km from the auction site.

Fishing grounds for Mkokotoni varied from the large sand/mud flats and adjacent mangrove forests of the nearby enclosed bay, to fishing grounds two hours sailing west of Tumbatu Island (Map 2). The nearest coral reefs to Mkokotoni were 4-7 km away. The depths fished, as reported in interviews, ranged from the exposed flats and reef crest to over 120 m for *dema* trap fishing.

METHODS

We conducted a trial weighing in Matemwe to see if landings could be estimated. We then met with representatives of each gear type in each village to outline our proposal and request permission to weigh the deliveries and determine how best to minimise interference with their activities. We then conducted sampling for 12 months (April 1995-March 1996). Following the first year of sampling (Year 1), we re-designed the sampling and again met with fishers to thank them, and

request permission to continue with the new format. We also conducted the first of two interviews on fish biology and fishing methodology with representatives of the principal gear types. We weighed landings for an additional 12 months in Year 2 of the study (April 1996-March 1997) and then met with village and representatives an additional time.

During Years 3 and 4, we changed the emphasis from trying to estimate total landings at the landing site to a study of a small number of representative fishers whose landings we followed through three 29-day lunar cycles. These data will be summarised in subsequent reports.

During Year 1, the choice of sampling days was biased towards days corresponding to spring tides. Fishers had requested that we only sample during spring tides. Field sampling was also not conducted during periods of heavy rains.

We adopted a stricter sampling scheme in Year 2. In Matemwe, we stratified our sampling by season and within season to include one cycle between peak spring tides. Sampling was conducted during four periods corresponding to the middle of the two monsoon periods (December and June) and the two transition periods (April-May and October). We sampled every other day between the day of the new moon (day 1) and the day of the old moon (usually day 14 or 15). We therefore tracked landings from the peak of one set of spring tides, through the neap tides following the new moon, and then to peak tides of the old moon. We omitted the neap period following the old moon. Sampling was conducted in all weather conditions.

During the two months between these four periods of intensive sampling, we augmented our core sampling with one additional day per month. These alternated between the new and old moon spring tides. This emphasis on spring tides was to obtain a better mean and variance estimate for the days of peak landings, as well as collect additional information and species composition during those days when most of the landings occurred.

The sampling team was composed of I.M.S. and S.C.F. staff. We intercepted the fisher before the auction site and weighed the catch to the nearest kg on a spring balance suspended from a tripod. While weighing the fish, we obtained information on gear and vessel. Species composition was resolved to family in the field (Bianchi 1985). Unknown species were collected for later identification when possible but some fishes were recorded as unknown. Fishers would not permit us to disconnect their string and sort the fish, so we classified the string by dominant species. If more than one family were present on the string, the most dominant by weight was classified as family #1. The second and third most

dominant were recorded as families #2 and #3. If more than three families were present on the string, #3 was called "mixed". We attempted to count the fish at the start but found this was not possible, except for octopus.

At the beginning of Year 2, the fishers requested that we move further from the auction site, towards the water line. Fishers reported that stating the weight during our sampling tended to lower the subsequent price in the market. Knowledge of the weight damaged the illusion of greater volume that fishers strove to achieve by the manner in which they strung the specimens on the strand of rope.

We suspected in Year 1 that we may have double counted some of the landings if two fishers from the same vessel approached the weigh station at different times. We also noticed on some occasions that vessels did not stop at the auction site. We assumed that these vessels had not caught enough fish for a sale. We addressed this possible bias in Matemwe by independently counting the number of vessels, fishers and gear types at the water's edge. We also enumerated the vessels before and after the auction by walking the beachfront. It was not possible to count at the water's edge in Mkokotoni because the deliveries came from too many different directions. These additional data from Matemwe allowed us to calculate catch rate (CPUE) for Matemwe in Year 2. That was not possible for Year 1 for Matemwe or either year in Mkokotoni.

For these calculations of catch rate we classified landings by vessel according to reported gear type. If multiple gears were used aboard one vessel, the trip was broken into fractions. For example, a mixed *dema* trap/handline trip was converted to 0.5 trap landings and 0.5 handline landings.

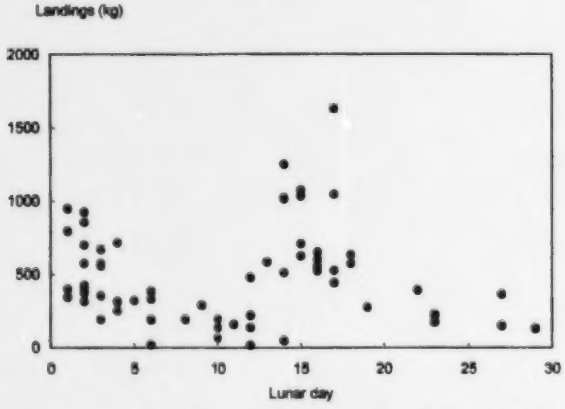

Figure 2. Daily landings in Matemwe by lunar day, April 1996-March 1997

RESULTS

We estimated landings on 65 days in Matemwe and 49 days in Mkokotoni from March 13, 1995-March 22, 1997. Landings in Matemwe were strongly correlated with the lunar cycle. Peak landings occurred during spring tides (Fig. 2). There was a modest indication that landings were higher during the spring tides of the old moon (days 14-17) than those of the new moon (days 1-4). A LOESS fitting procedure is described in Jiddawi, Stanley and Kronlund (in prep).

We assumed that the correlation between the lunar-tidal cycle and diurnal landings fishing would be caused by tide height that controlled access over the fringing reef. Fishers had commented in our study, as in that of Tobisson et al. (1998) that when the high tides are too late in the day, during the waning tides, it makes it difficult to complete the auction and transport the fish to market before dark. Variation in catch rates is discussed below.

We observed a similar but much less obvious lunar/tidal correlation in Mkokotoni (Fig. 3). Landings tended to be higher in Mkokotoni during spring tides, but unlike Matemwe, the largest landings occurred in association with spring tides of the new moon, not the old moon. There is also a modest indication of lower landings in the second phase of neap tides. The modest influence of the tidal cycles in Mkokotoni seemed be caused by net fishing. All other gear types appeared to show little correlation with lunar day.

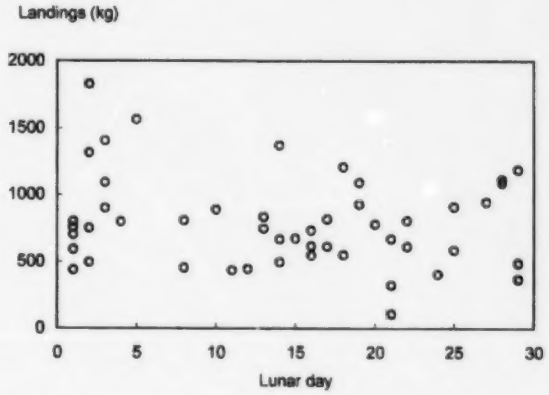

Figure 3. Total daily landings in Mkokotoni by lunar day, April 1996-March 1997

As indicated above, fishing activity was reduced on specific days. We observed a tendency for lower landings on Fridays, the Muslim day of prayer. We were informed that fishers often do not go fishing during funeral days.

Fishers reported to us, that fishing was reduced during seasons of strong winds. Winds were reported to be strongest on the east coast during the southern monsoon (June-September). During Matemwe sampling in June of Year 2, fishers reported three of seven days had strong winds as compared with 1/8, 0/7, and 0/6 days for the September, December and March fortnight sampling periods. This was consistent with fishers' comments but data were too sparse to conduct formal statistical analysis.

Estimates of annual catch

Since our choice of sampling days was not random with respect to lunar day, we first fitted a predictive regression to landings by lunar day. We generated bootstrap estimates of the annual landings for both Matemwe and Mkokotoni by calculating 500 bootstrap estimates of the landings of one "typical" lunar cycle. From these 500 results, we calculated a mean, median and 95% confidence limits (Jiddawi, Stanley and Kronlund, in prep). Each of the bootstrapped estimates was generated by summing the predicted value for each of the 29 lunar days but where each of the 29 predicted values was first altered by adding to the predicted value, a residual, sampled with replacement, from the total population of residuals. We used the predictive fit to the lunar cycle and bootstrapping to generate 500 estimates of the total landings of 1 lunar cycle. The estimate of mean catch for a lunar period in Matemwe was 10.48 t; the estimate of the median was 10.50 t with the 95% confidence limits of the mean of 8.36-12.70 t. The mean and median bootstrapped estimates for a lunar cycle in Mkokotoni were 19.70 t and 19.72 t. The 95% confidence limits of the mean was 17.23-22.19 t.

Multiplying mean catch and the 95% confidence limits per lunar period by the number of 29.4 day periods per year, 12.4, provides an estimate of annual catch and variance. Our estimates of annual landings with 95% confidence limits were therefore 130 t (104-157 t) for Matemwe and 244 (214-275) t.

Landings by vessel and gear

Double-outrigger canoes dominated landings in Matemwe, while dhow landings dominated in Mkokotoni (Fig. 4). Net, handline and stick/spear dominated landings in Matemwe (Fig. 5). In Mkokotoni, net and *dema* trap dominated landings. Not shown are total landings in Mkokotoni of 1 kg of sea cucumbers and 10 kg of crabs. These were collected in a weir.

Species composition

We observed 61 different families in the landings (Table 1). These included eight families of invertebrates, nine families of cartilaginous fishes, 43 families of bony fishes, and 1 marine mammal. The only major distinction between the two villages were the presence of the mangrove inhabitants such as sand lobster

(Scyllaridae), prawns (Penaeidae) and crabs (Portunidae), as well as one porpoise in the Mkokotoni landings.

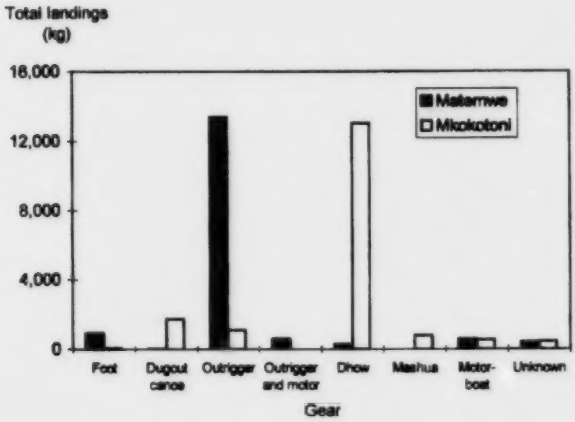

Figure 4. Landings by vessel type in Matemwe and Mkokotoni, April 1996-March 1997

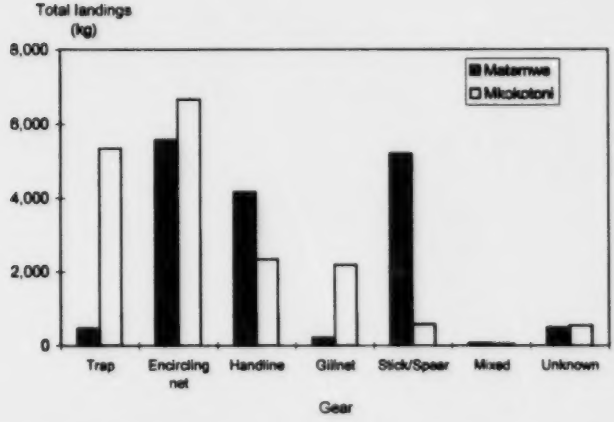

Figure 5. Landings by gear in Matemwe and Mkokotoni, April 1996-March 1997

To present relative importance, we allocated each weighing to the primary family (#1) if more than 1 family recorded to the landing. The majority of the fish landings in both villages were the typical reef fishes such as emperor (Lethrinidae), rabbitfish (Siganidae), snapper (Lutjanidae), parrotfish (Scaridae), mullet (Mullidae), grouper (Serranidae), surgeonfish (Acanthuridae), and moray eel (Muraenidae). Mkokotoni landings included a significant component of pelagic piscivores including large mackerel (Scombridae), trevally (Carangidae), and requiem sharks (Carcharhinidae). Octopus dominated landings in Matemwe but was the eighth most important group in Mkokotoni. Mkokotoni fishers commented that some of the octopus captured by Tumbatu Island fishers were being shipped directly to Mombasa, Kenya.

Table 1. Frequency of observations by fish family observed in the landings

Type	Family	Matemwe	Mkokotoni	Total
Unknown	Unknown	9	33	42
Invertebrates	Octopodidae	882	248	1,130
	Loliginidae	40	172	212
	Holothuriidae	41	2	43
	Palinuridae	7	33	40
	Sepiidae	0	39	39
	Portunidae	0	29	29
	Scyllaridae	0	3	3
	Penaeidae	0	1	1
Cartilaginous fishes	Dasyatidae	135	129	264
	Carcharhinidae	9	33	42
	Myliobatidae	3	16	19
	Mobulidae	1	4	5
	Rhinobatidae	0	3	3
	Alopiidae	1	0	1
	Scyliorhinidae	0	1	1
	Sphyrnidae	1	0	1
	Squatinidae	0	1	1
Bony Fishes	Lethrinidae	546	721	1,267
	Siganidae	422	639	1,061
	Scaridae	484	438	922
	Lutjanidae	308	368	676
	Mullidae	264	287	551
	Serranidae	305	126	431
	Acanthuridae	163	91	254
	Haemulidae	72	165	237
	Muraenidae	178	20	198
	Carangidae	82	101	183
	Gerreidae	13	165	178
	Scombridae	11	160	171
	Labridae	69	74	143
	Belonidae	21	116	137
	Sphyraenidae	15	97	112

	Diodontidae	93	4	97
	Nemipteridae	2	83	85
	Hemiramphidae	0	72	72
	Caesionidae	18	50	68
	Ariidae	1	57	58
	Coryphaenidae	20	17	37
	Fistulariidae	2	29	31
	Drepanidae	12	14	26
	Pomacentridae	24	2	26
	Chirocentridae	0	23	23
	Rachycentridae	3	15	18
	Istiophoridae	3	14	17
	Balistidae	10	4	14
	Teraponidae	1	8	9
	Trichiuridae	0	8	8
	Platycephalidae	2	5	7
	Clupeidae	3	3	6
	Mugilidae	4	1	5
	Ostraciontidae	5	0	5
	Psettodidae	0	4	4
	Chaetodontidae	3	0	3
	Sciaenidae	0	3	3
	Cynoglossidae	0	2	2
	Echeneidae	1	1	2
	Leiognathidae	0	2	2
	Platacidae	1	1	2
	Scolopsidae	1	1	2
	Tetraodontidae	1	0	1
Mammals	porpoise	0	1	1

Rabbitfish dominated the *dema* trap catches in both villages, although actual *dema* trap landings of rabbitfish were 20 times greater in Mkokotoni. The handline landings in Mkokotoni reflected a higher proportion of deeper water pelagic piscivores including requiem sharks, tuna, trevally, and mackerel whereas handline catches in Matemwe were dominated by families which inhabit waters closer to the reefs, such as emperor, snapper and rabbitfish.

The species composition data for net fishing are difficult to interpret because they include catches from a wide variety of net types, as discussed earlier, however, volumes are probably dominated by the drive-net fishing. In Mkokotoni, the diversity was very high with the dominant 10 species accounting for only 74% of the landings. In Mkokotoni and, to a lesser extent Matemwe, net fishing produced significant quantities of small barracuda (Sphyraenidae). As with other gear, reef or near-reef fishes dominated net landings. Octopus dominated the stick/spear landings. Most are captured with a hooked stick as fishers walked on the reef crest. A large volume of rays was captured with spears in the shallow sandy flats in front of Mkokotoni village.

Effort

The number of outrigger-canoe daily trips in Matemwe was closely related to the lunar-tidal cycle but we observed no relationship between lunar day and the number of trips made on foot. The number of fishers per vessel peaked during spring tide with the average increasing from 2.6 during neap tides to 3.6 during the spring tides. Apparently, vessel owners charged fishers approximately $US2 to accompany a trip. The lateen rigging of the sails is reputed to be difficult to operate by 1 person (Wilson and Davy 1993). This probably precludes trips by solitary fishers in the larger double-outrigger canoes.

Among trips reported to use only one gear, trap and handline trips averaged 2.4 fishers per vessel. Spear and octopus stick landings averaged 3.4 fishers per vessel, and those using nets averaged 6.9 fishers. One motorised vessel landing in Matemwe had 18 fishers on board. Fishers, using encircling nets averaged 3.3 fishers/landing while those travelling in double-outrigger canoes vessels averaged 5.5 fishers/landing. Some involved over 15 fishers. In Mkokotoni, dhows that used encircling nets often had 35-40 men and boys aboard.

CPUE (catch-per-unit-effort)

Accurate estimates of CPUE were calculable for Matemwe in Year 2. However, because landings estimates by vessel and gear were derived at the auction site, while effort by gear and vessel was estimated separately by counting at the water's edge, catch rates were estimated from pooled data for each day. Thus, the point estimates are un-biased but could not be used to calculate the variance.

Catch rates averaged 4.0 kg/person for those fishers who travelled to their fishing locations by foot. It was 4.5 kg/person for those that travelled by outrigger-canoe, and 9.8 for those that travelled by larger vessel (dhow, *mashua*, and motor-boat). Landing per vessel for the outrigger-canoes was 14.3 kg/day and 85.8 kg/day for the larger vessels. By gear-type, average catch/landing varied from 8.3 kg/landing for *dema* trap fishing to 72.0 kg/landing for net fishing (Table 2). Catch/fisher-day varied from 3.7 kg for *dema* trap fishing to 8.6 kg for net fishing. We did not collect any information on number of traps or number of net sets.

We did not make any direct observations regarding actual number of hours fished but through our interviews it is possible to provide general estimates for Matemwe. Since fishers leave about dawn (0600) and the auction takes place between 1300-1500 hours, an average trip is 7-9 hours. We can assume approximately 2-4 hours for the round trip leaving approximately 3-7 hours of fishing time. The likely catch rate per fisher-hour can be presented as a plausible range (Table 2). There was no evidence for a strong effect of lunar day on catch rate (Table 3) but data were limited.

Table 2. Catch rates by landing, fisher-days and fisher-hours for Matemwe, Year 2.

Gear	No. ldgs.	Total number of fisher-days	Total catch (kg)	Kg/ldg	Kg/fisher-day	Kg/fisher-h (3-7/trip)
Dema Trap	36.5	81.5	304.0	8.3	3.7	0.53-1.24
Handline	332.0	848.7	2,959.0	8.9	3.5	0.50-1.16
Spear/stick	308.0	898.3	3,539.7	11.5	3.9	0.56-1.31
Net	55.5	462.5	3,995.9	72.0	8.6	1.23-2.88
Total	732.0	3,023.00	13,821.6	18.7	4.7	0.65-1.53

Table 3. Average catch per fisher-day by gear and lunar day, Matemwe, Year 2 (nd = no data)

Lunar day	*Dema* trap	Handline	Net	Overall
2	4.29	1.89	8.55	3.87
3	3.33	2.14	8.82	4.50
4	3.71	3.00	1.03	2.17
6	1.57	3.15	4.08	4.12
8	3.50	nd	17.14	8.80
9	4.50	2.11	nd	2.77
10	2.14	2.53	nd	3.13
11	nd	2.34	nd	2.65
12	1.75	4.03	3.44	4.41
14	7.59	5.74	15.47	7.10
16	5.60	4.55	18.25	6.75

Timing and duration of the auction

The access and timing problem for Matemwe fishers returning over the fringing reef creates not only a predictable lunar cycle in catches, but also a predictable auction time. Figure 6 indicates the arrival time of the first outrigger-canoe versus time of the high tide for that day.

It is obvious for those days during the spring tides, when the tide peaks between 1-8 PM, the first vessel arrives about three hours before the peak of the tide. There are two outliers within the range consistent with spring tides. In both cases, a solitary vessel landed a few hours before the remaining vessels.

The relationship of auction timing and tides can be expressed in relation to the time of peak tide or tide height. At the time of the auction, the height of the rising tide is always about 200 cm during the days of spring tides. Since it takes 30-60 minutes for the boats to get to the auction after clearing the fringing reef, they

must require a tide height in excess of 200 cm probably in the range of 250-300 cm to clear the break in the reef. This is consistent with the lack of activity during the period of neap tides when the maximum high tide may only reach 250 cm on lunar days 9 and 25. During the neap tides, when the high tide peaks before 1 PM or after 8 PM, timing of the arrival of the first of the few vessels that do fish is less predictable.

The tidal cycle had less of an effect in Mkokotoni where there was no fringing reef to inhibit activity; however start of the auction showed a slight tendency to become later in the day as the spring tides became later. Fishers appear to use the rising time to return to the auction site over the large tidal flats.

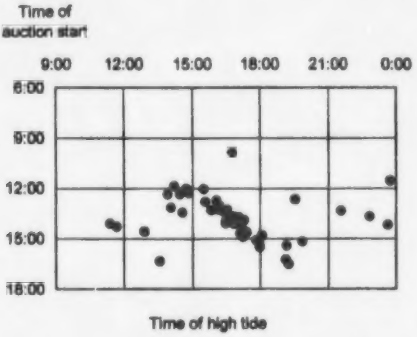

Figure 6. Time of auction vs. time of daytime high tide in Matemwe, April 1996-March 1997

Comparison with official statistics

It was possible to obtain official landings estimates for 15 days at Matemwe and 22 days at Mkokotoni that coincided with our observations. The comparison indicates no correlation between the two data sources (Fig.7).

DISCUSSION

The project demonstrated that the auctioned landings from the diurnal fishing activities could be estimated with a simple hanging scale. The 65 and 49 days in Matemwe and Mkokotoni provided statistically defensible and precise estimates of annual production of 130 t (104-157 t) and 244 t (214-275 t) respectively. Once the fishers were accustomed to our activities, estimation of landings required a minimum of three people: a recorder, a person to weigh the fish and a

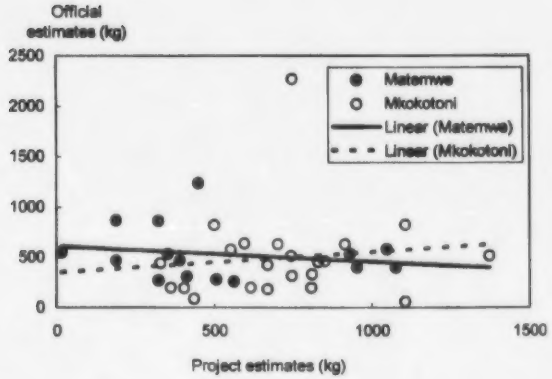

Figure 7. Comparison of Project vs Official estimates of daily landings in Matemwe and Mkokotoni

person to guide the landings through the weigh site. The cost in time over the two years of observations totalled 333 person-days. The current design of the official S.C.F. sampling requires 1,152 person-days for the same period. The methodology presented herein is documented, repeatable, and precise.

While recording landings and providing a methodology, we documented an important relationship between fishing activity in Matemwe with the lunar/tidal cycle. While discussed in Tobisson *et al.* (1998) from interviews, we have shown quantitatively the impact of the periodicity and how it can vary among villages. Most of the reduction is explained as fewer vessels travelling to fish. A minor component is that fewer fishers per boat operate during these tides.

This periodicity of landings among villages on the east coast is obviously known to the fishing community, as well as local fisheries and scientific staff. However, we know of no previous work that documented the magnitude of the effect or could partition the relative importance of the influences of number of vessels or fishers and catch rates. Cordell (1974) and Johannes (1981) both provide fascinating accounts of the lunar and seasonal rhythms of fishing activity in Brazil and Palau respectively. Tobisson et al. (1998) summarized fishing patterns of Chwaka Bay, Zanzibar from interviews but none provided any quantitative evidence of the impact of these activity patterns.

Interviews with fishers revealed knowledge of the additional impacts of seasonal and lunar influence on fishing success, apart from issues of access (see also Johannes 1981). Mkokotoni landings indicate a modest lunar periodicity of

landings. We suspect that with more detailed data on species composition by gear type, we would observe interaction between catch rates of certain species and lunar or seasonal cycles.

We demonstrated that total landings by gear and vessel type can be recorded by 2-3 people at the auction site. However, we also found that this simple process does not generate unbiased estimates of fishing effort, since it misses the vessels with little or no catch that bypass the auction site. Catch rate (CPUE) data can be improved by interviewing fishers at the water's edge, as in this project, or through on-board observers (Guard 1999), or through tracking specific fishers over time with interviews or logbooks.

Catch composition

We were successful in identifying catch composition to the taxonomic level of family. This alone indicated that the fishers from the two villages exploit at least 61 families. With the exception of octopus, we did not succeed in estimation of size composition or record catch to species. Many of the fish strings had more than 1 species. Breaking all the strings in order to sort or measure the fish would be too much of an imposition to the delivery and auction process. We were also informed that breaking the string would result in lower prices being paid to the fishers. The stringing process was perceived as an important skill that affects the price. The project was, however, successful in counting and weighing octopus and demonstrating the value of these data (Mhitu and Jiddawi 1999).

Exploitation levels

In providing baseline information on species composition to family, and catch rates, we have not only proven a methodology, but also provided the first estimates of a potential time series and abundance index. Future work can repeat the methodology and examine how fishing landings have altered with respect to species diversity, catch rates and activity patterns. During interviews, fishers indicated 14 families of species groups for which at least one species is thought to be less abundant (Table 4). Future comparisons could pay particular attention to these groups. The methodology could be repeated every five to ten years to test for evidence of declining productivity or biomass in Unguja Island as manifested by catch rates and diversity.

Table 4. List of fish families for which at least one species was reported by fishers to be less abundant in recent years

Matemwe	Mkokotoni
One unidentified ornamental shellfish	Sea cucumber
Lobster	Some species of sharks
One unidentified species of shark	Trevally
Triggerfish	Herring
Trevally	Mullet
Emperor	Marlin
Cobia	Mackerel
Parrotfish	Rabbitfish (mixed opinion)
Grouper	

Species composition and one-time estimates of catch rates can also provide crude indicators of stock status (Jennings and Lock 1996, Jennings and Polunin 1966a, Munro 1996 and Ruddle 1996b). Munro (1996) comments that the changes arise because the larger predatory species, which tend to be vulnerable to a wider range of gears and are usually more desirable, are specifically targeted. Koslow *et al.* (1988) reported for trap fisheries in Jamaica, that the fishery shifted from grunts (Pomadasyidae) and surgeonfish to squirrelfishes (Holocentridae) and the virtual disappearance of parrotfishes. The abundance of surgeonfishes and parrotfishes in trap catches in both villages of this study suggests that these fisheries have not yet reached the state of overfishing reported for Jamaica.

Munro (1996) suggests that parrotfishes can only be caught by traps, nets or spears but this group was significant in Matemwe handline fishing. That a family not particularly susceptible to a gear type is caught in Matemwe would imply a significant abundance is still present. However, parrotfish were virtually absent (<0.04%) from Mkokotoni handline landings. Munro (1996) also reported at one site a shift from triggerfish to squirrelfish and puffer fish in response to increasing exploitation. None of these families was important in our two villages, but it is interesting that fishers in Matemwe commented that triggerfish were becoming less abundant.

Lock (1986), summarised in Jennings and Lock (1996), suggested three levels of exploitation effects in multispecies and multigear fisheries. He suggested that with light to moderate fishing, catch rates were high with large herbivores (surgeonfish) dominating the spear and net catches and large predatory groupers and snappers dominating the line catches. Emperors dominated in the moderate exploitation phase. In the heavily exploited phase, handlining was replaced entirely by netting of rabbitfish.

Matemwe catches tended to be dominated by snapper, emperor and grouper, the classic handline mix. Mkokotoni exhibited a more unusual mix with few grouper and a significant mix of shark and tuna-like species. This reflects fishing further from the reef. Dalzell (1966) suggests that catch rates per hour of 0.5-2.0 per line/h is common for shallow handlining. This compares with the 0.5 - 1.16 kg/fisher/h observed in Matemwe.

The *dema* trap catches of mostly herbivorous fishes (rabbitfish, parrotfish and surgeonfish) and small scavengers (small emperor) reflect that the fishing takes place close to the reef. We observed a catch rate per fisher-day of 0.5-1.2 but it was not possible to compare with Dalzell's summary as his catch rate was expressed per *dema* trap.

Mkokotoni fishers reported four types of *dema* trap fishing. They set small traps for emperor in a depth of 6 m. The traps are baited with clams and set overnight. A second type of trap is designed for rabbitfish. These traps are baited with algae and suspended from poles in about 4 m depth. These are not left overnight to soak. A third type includes larger traps put in stony areas, 24-30 m in depth. They are baited with brittle stars for triggerfish and parrotfish. A fourth type of trap fishing is conducted in 100-120 m for larger grouper, parrotfish and snapper. That deeper water trap fishing is still productive for valuable large piscivorous species implies that deeper fishery grounds of Mkokotoni may be only moderately fished.

Octopus and ray dominate the spear or stick landings from fishers who walk on the reef or on the sand flats. Most of the other fish landed using the stick/spear category were probably captured with spears or spear guns while free diving. The landings of parrotfish, grouper, surgeonfish and moray eel reflect that most of the spearfishing takes place very close to the reefs. Dalzell (1966) comments that while published records of spearfishing range from 0.4-8.5 kg fisher-h, most of the observations (90%) are less than 2.4 kg/fisher-h, similar to our estimates of 0.56-1.31 kg/fisher-h.

We were not able to distinguish during interviews between various forms of encircling nets. Thus, our net landings combine those of small and large beach seines, and drive-net fishing. This is reflected in the high diversity of species composition in the Mkokotoni landings where the top 10 groups only account for about 2/3 of the landings. The landings reflect mainly reef species and small pelagic species like fusilier and ponyfish. Dalzell (1966) reported catch rates from net fishing of 0.2-3.9 kg/fisher-h similar to our observations of 1.2-2.9 kg/fisher-h.

The information gathered in the present study provides insight into the possible status of the coral reef stocks. Fishers in both villages reported that many groups seemed less abundant. The composition in the landings of the two Zanzibar villages appears to correspond to light to moderate fishery exploitation as summarised above. The landings of Mkokotoni implies a higher level of exploitation in that net fishing plays a more dominant role and these landings are dominated by rabbitfish with fewer surgeonfish and parrotfish. The differences are also related to different habitats. Grouper play a lesser role in the handline landings. Furthermore, octopus, which are easy to capture, play a much lesser role in Mkokotoni, and more of the production is reputed to be captured by diving instead of walking on the reef crest.

Catch rates, although crudely estimated in the present study, are at the low end of those published elsewhere. The high diversity of species in the catch compositions is encouraging but the apparently low catch rates and the comments by fishers that some species are much less abundant is a source for concern. While we could not in the course of this brief survey of landings establish the status of the fishery stocks of Zanzibar, we have provided a first look at the relative status compared to other fisheries in the world. We have also provided baseline observations which can be followed over time.

Fishing activity

In addition to providing information on stock status and utilisation, data provided in the current study provide managers with a better understanding of how the fishery is prosecuted. Since fishery management is never managing fish, only people, it requires an understanding of how fishers exploit the resources before implementing regulations (McManus 1996).

Collaborative working relationships with the fisherfolk

Finally, the project was successful in developing a positive research and working relationship with the fisherfolk in both villages. While the fishers were initially antagonistic, by the end of the two years of study, the cooperation had reached the point where the auctioneers refused to market the catches until they were weighed. The fishers were also willing to converse about their fishing practices and expressed appreciation for the attention their fishery was receiving.

Suggestions for future work

- Expansion of the Matemwe/Mkokotoni study

We have demonstrated the value of landings data. We recommend that this methodology be expanded to collect better catch rate and species composition data. These observations could be combined with spatial analysis of the fishing grounds to calculate harvest per unit area. The same project could take advantage

of the natural experiment provided by the impact of the fringing reef. Catch rates, species diversity, and size composition could be compared among east coast villages, some of which have tidal access problems and only fish half the time versus other villages which have constant access.

In the first phase we examined landings at a gross level with respect to species group. We also recorded fishing activity by gear and vessel type and usage with respect to tidal and seasonal periodicity. We obtained few specific details on fishing techniques and how specific deployment of gear is conducted or can vary with changing seasonal or tidal conditions. The objective of the next phase would be to show how systematic sampling of landings can provide information at one additional level of detail, that of the individual species and the specific gear.

- Home consumption and the role of women and children in fishery harvests

A deficiency of both the present study and the official data scheme is the absence of information on the amount of fish retained for home consumption and the harvesting from gleaning in the intertidal zone. As prices continue to rise for the more valuable products from the vessel-based fishery, village families may become increasingly unable to afford to eat their own catches and may increasingly rely on the results of the "subsistence" harvesting. This study would have to be done within the village home through systematic interviews and could easily incorporate other sociological issues related to the traditional fishery.

- Traditional management

We have shown how to collect landings data to provide a basis for resource assessment and provide an improved understanding of how the fishery is prosecuted. However, better harvest data alone with not solve the problems of fishery management that is beset with limited resources in a diverse harvesting context. These problems have led many to emphasise the value of using existing traditional management practices (Ruddle 1996b). As there is some evidence for such practices in the southern portion of Unguja Island (Narriman Jiddawi, 1997), we recommend that future studies document the existence and efficacy of traditional management on Unguja and Pemba Islands.

- Documentation of traditional fishing practices and biological knowledge

We have discussed the importance of knowing how fisheries are prosecuted prior to implementing management. We suggest that an in-depth study of the various fishing practices and compilation of local knowledge be conducted in select villages. This background information will be invaluable for designing future scientific research and new management regimes (Johannes 1981).

- Spatial analysis of the fishing grounds

An asset for most of the projects discussed above would be a charted (GIS) classification of the fishing grounds within the zone used by traditional fishers. The objective would be to classify and quantify the depth and bottom type. This would be especially useful if it could be allied with a documentation of the local areas used by each of the villages. In conjunction with harvest estimates, it would provide estimates of productivity.

- Study of women fishery co-operatives

Previous work has revealed the presence of two women's fishing co-operatives in the village of Nungwi, northern Unguja. They are independent of any government initiative and are based on the joint purchase of a beach seine. We propose a two-part study of this co-operative. Firstly, a series of interviews would elaborate the history, structure and function of the co-operative. Based on these discussions, the team would then conduct field trips to Nungwi to document the catch weight and composition and record the distribution of proceeds. Information from this study could be used as a basis for encouraging this practice in other communities. It will also provide the accompanying information on whether this particular sub-fishery of the artisanal sector is "optimising" the productivity of these resources, or harvesting coral fishes at too small a size.

- Octopus biology and fishery

We suggest that the octopus fishery is an important study area. It is important not only for revenue and consumption, it is also the preferred bait for hook-and-line fishing and reputed to be important for cultural occasions. In some villages only women may harvest this fishery while in others, only men. There is also some suggestion that some villages are already exercising traditional management controls over the harvest of these species. These species and their fishery would be an excellent biological study target because they are easily collected and sampled. The various villages may be convinced of conducting adaptive management studies where the impact of reducing or increasing harvest could be experimentally manipulated.

RECOMMENDATIONS

While the importance of these fisheries for protein, income, foreign exchange, employment and culture is well understood, the status, or relative health of these resources is not known. Also unknown is the nature and extent of the ecological impact of the current harvesting procedures. In addition to possible short-term reductions in productivity, perhaps the current fishing is causing irreversible changes through damage to the reef itself or by incurring ecosystem shifts (Jennings and Polunin 1996b).

We have with the present project attempted to show how relatively simple research methods can provide a basis for stock assessment of the traditional fisheries of Zanzibar. Specifically, the project:

- established a working relationship with the SCF;
- showed how academic and government fisheries staff could develop a productive working relationship with the fishing community;
- showed that with only a spring scale and the co-operation of the fishers in two village, we could provide statistically rigorous first estimates of catch rates and species compositions;
- demonstrated that the current expectations for the beach recorders are not realistic;
- provided a baseline data set that future studies can use to optimise their sampling design.

We recommend that this project serve as a model for expansion of harvest data collection activities, where the focus is on high quality data to complement the current broad based census style.

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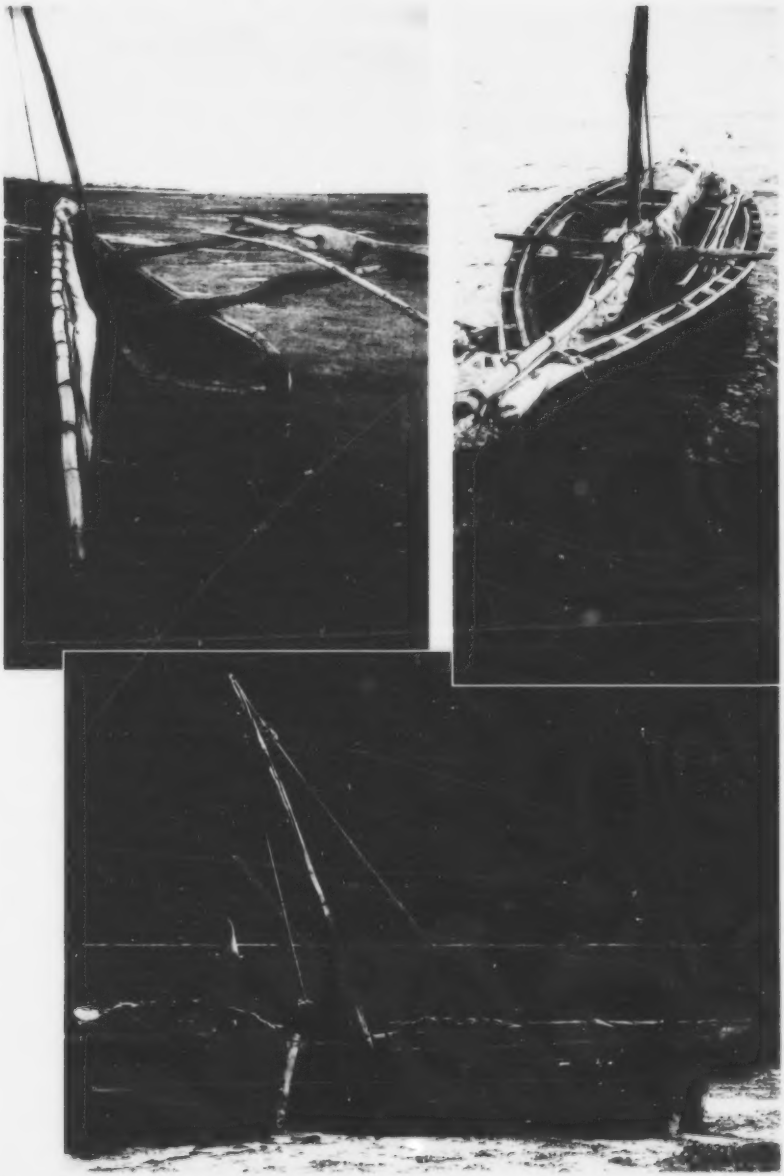
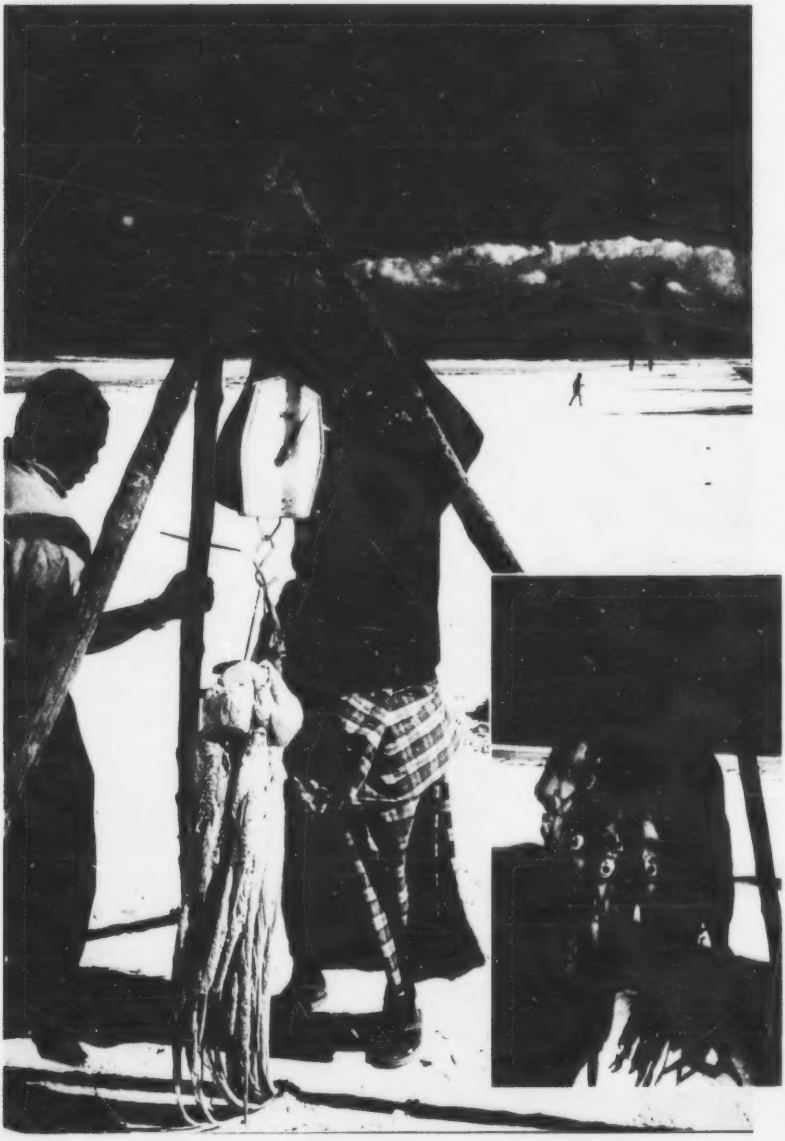


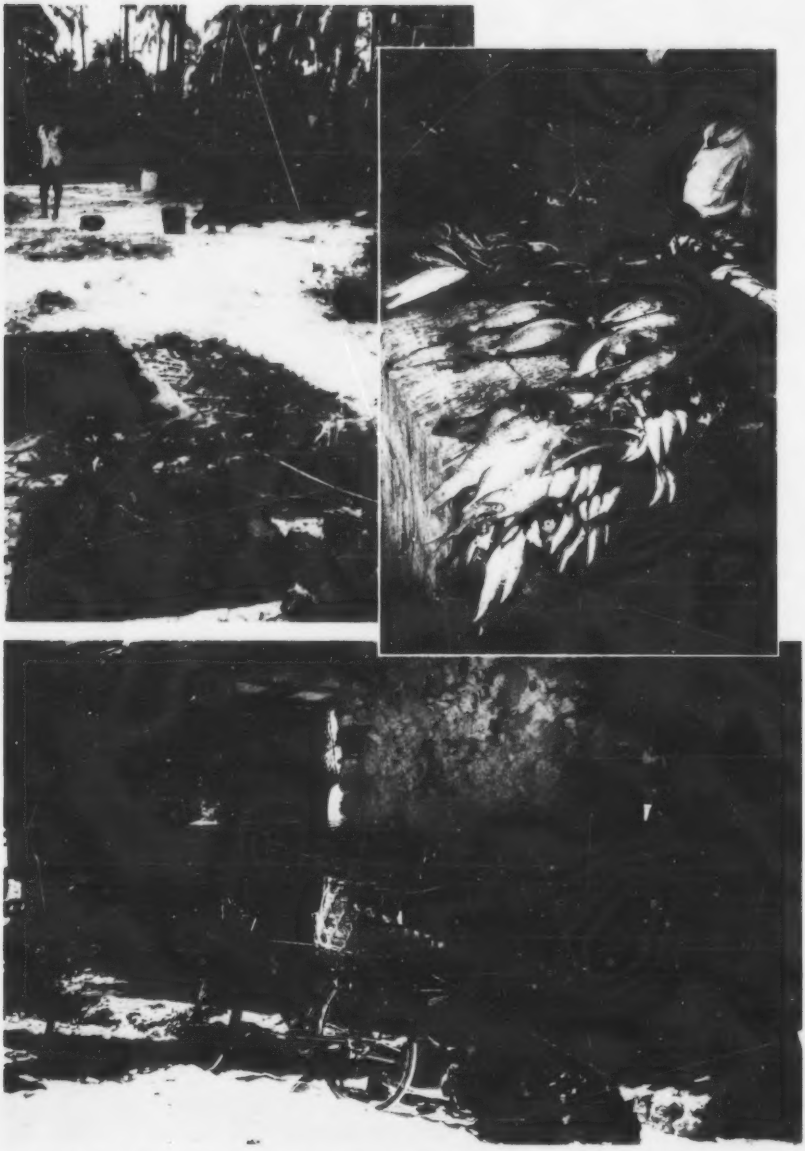
Top left: Dugout with outrigger at Mkokotoni (*Ngalawa*). *Top right:* Dhow at Mkokotoni (*dau*). *Bottom: Mashua* at Matemwe. (R.D. Stanley)

Top: Ngalawa returning to auction site at Matemwe. *Bottom: Ngalawa* at Matemwe auction site. (R.D. Stanley)

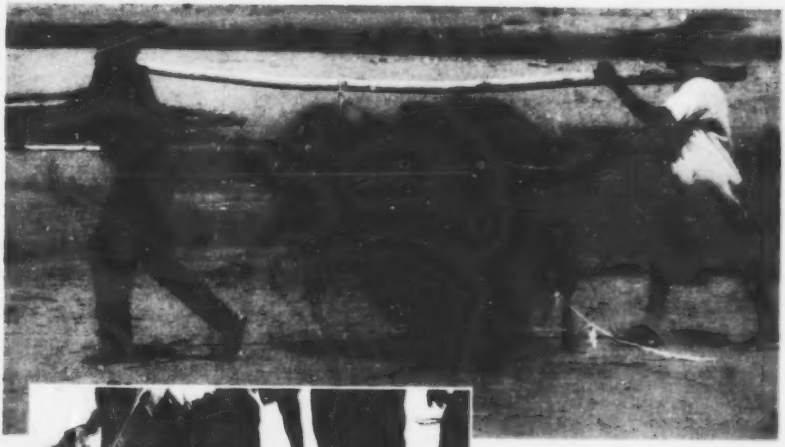
Above: Fishers bring fish to Matemwe auction site. *Top right:* Weighing trevally at Mkokotoni auction site. *Bottom right:* Weighing catch of fish at Matemwe auction site. (R.D. Stanley)



Weighing catch of octopus at Matemwe. *Inset:* Weighing catch of squid at Matemwe. (R.D. Stanley)



Top left: Sea cucumbers drying in Zanzibar. (University of Guelph) *Top right:* Fish market in Mkokotoni. *Above:* Bicycles waiting to deliver fish in Matemwe. (R.D. Stanley)



Top: Carrying seine for small pelagics in Zanzibar. (M. D. Richmond)

Left: Assembling *dema* trap in Matemwe. (R. D. Stanley)

Bottom: Setting gillnet from *mashua*. (M. D. Richmond)

Top left: Manta ray in Mkokotoni market. *Top right:* Sailfish being delivered to Zanzibar market. (R.D. Stanley) *Above:* Marlin on beach at Nungwi. (M. D. Richmond)

Above: Boy pounding octopus in Matemwe.

Right: Sun-dried octopus stomachs used for rabbitfish bait.

Below: Sun-dried octopus stomachs (as left). (R. D. Stanley)

Section III: Studies of Specific Fisheries

The status of the crab fishery at Mzinga Creek, Dar es Salaam

Abdilahi I. Chande, Alfeo M. Nikundiwe and Joel Kyomo

INTRODUCTION

Mzinga Creek is located in the southern part of Dar es Salaam. It branches upstream into the valleys of the Mzinga, Yombo and Mbagala Rivers (Fig. 1). Marine or brackish water fills the creek most of the time; however, there is considerable freshwater discharge during the main rains. The substratum of the creek is clay-bound sand (Temple 1970).

Many artisanal fishers (13 boats), mainly targeting on finfish and prawns, fish the vicinity of Mzinga Creek with beach seines and castnets. Those using castnets operate on foot and target on prawns while the beach seine fishers use dugout canoes fitted with outriggers (*ngalawa*). These vessels are propelled by paddles and target on both finfish and prawns. The canoes range in length from 7-11 ft. Although beach seine fishers usually target on finfish and prawns, they also catch significant amounts of crabs. Sometimes the crab catches dominate and become the target species group.

The crab catches are dominated by two portunid species, *Scylla serrata* (Forskal), commonly known as the mud or mangrove crab, and *Portunus pelagicus* (L.), commonly known as blue swimming or sand crab. *Portunus sanguinolentus* (Herbest) is occasionally recorded in the catch, but is less important. Previous work has summarised the distribution and importance of the two portunid species. In one survey of the crab fishery potential of Tanzania, it was suggested that about 20 t of live crabs could be harvested monthly from the Rufiji delta alone (Alverson 1971, Alverson and Patterson 1974).

Scylla serrata is the largest of the portunid crabs and can survive longer out of water than *P. pelagicus*. *S. serrata* is found throughout the tropical Pacific and Indian Oceans. It inhabits mangrove swamps, estuaries and sheltered bays where it digs deep burrows (Barnard 1950). It also inhabits the muddy bottoms of river mouths and other brackish waters along the shore (Sakai 1976).

The fishery and the distribution of *S. serrata* in Tanzania has been summarised in previous reports (Heath 1971, Alverson 1971, Alverson and Patterson 1974). Heath (1971) observed that *S. serrata* is the most important commercial crab in Tanzania but noted that its annual landings are fairly small. Bashemererwa

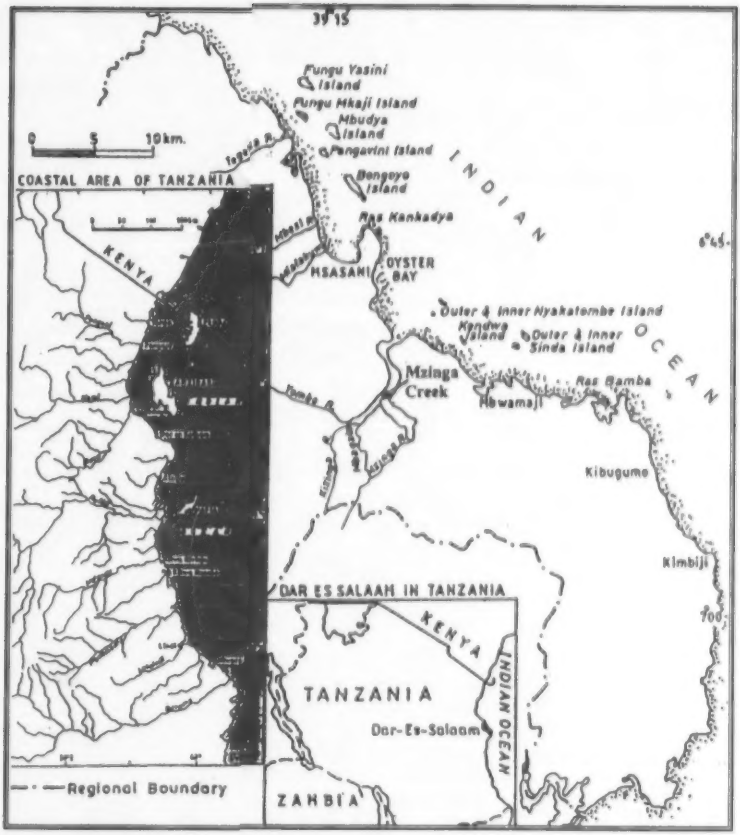


Figure 1. Map of Dar es Salaam coastline showing the study area (Mzinga Creek)

(1981) reported some biological aspects of *S. serrata* including the observation that spawning occurs in deep oceanic waters whereas the creeks are used for feeding and mating.

Portunus pelagicus is second to *S. serrata* in commercial importance. It is entirely aquatic and inhabits shallow coastal waters, including estuaries, sheltered bays and open sub-littoral waters. The substratum is usually sandy or slightly sandy-muddy (Potter *et al.* 1983).

The catch trends of the crab fishery that have been provided by some authors in Tanzania are estimates only. No thorough studies have been conducted to estimate the available stock and exploitation rate. Therefore, it was the aim of this study to investigate the fishing methods used to harvest the crabs and estimate relative abundance through analysis of the catch rates. Specific study objectives were to:

- document the crab harvesting methods;
- estimate the stock of crabs using beach seine net catch rates as an index of abundance;
- investigate the reproductive cycle of the crabs caught in beach seine nets.

METHODS

The study was conducted at Mzinga Creek. Detailed data were recorded by direct observation of beach seine net operations, while results of other fishing methods were estimated by interviewing fishers. The beach seine nets had codend mesh sizes of 17-19 mm and were 30-60 m in length. Fishing operations were usually conducted during low tides.

Samples were collected five days a month for one year, January-December, 1995. All captured crabs were sorted by species and sex and then weighed with a spring balance (50kg). Maturity state of the crabs was also recorded. In the case of *S. serrata*, they were recorded as mature or immature. The maturity state of the female crabs was determined by the shape of the abdomen. The abdomen of the immature females is narrow and triangular and its segments do not articulate freely. Abdomens of mature females are semi-circular with freely articulating segments. The shape of male abdomens do not change; however, the maturity states can be determined using the flexibility of the abdominal segments as a diagnostic feature. Those of mature males can be articulated freely, while immature males have a hinge or pin-like structure, which fixes the abdomen to the thoracic segments. The maturity states of *P. pelagicus* were determined using both the morphological changes of the abdomen and the stage of the gonads.

RESULTS

Fishers use various methods to catch crabs in the creek. Most *P. pelagicus* and *S. serrata* are caught as by-catch in the beach seines. However, significant landings of *P. pelagicus* also result from handpicking. This involves the tracing of the position where the crab has partially burrowed into the sand using a stick or a curved metal rod. Then the crab is firmly picked with hands by pressing the chelipeds to the carapace. The operation is conducted in shallow waters, less than 1 m depth. In addition to beach seines, *S. serrata* are caught using hooked sticks

or metal rods that are inserted into the burrows of the crabs. The crabs usually grasp the hooks and are then pulled from the burrows. The third and least important method used to catch *S. serrata* is handpicking those which walk freely on the creek banks or amongst the mangroves.

The highest catch rate of *Portunus pelagicus* was recorded in February at 2.5 kg/haul/100 m-net (Fig. 2). The lowest catch rate was in November at 0.09 kg/haul/100 m-net. Generally, catch rates were higher from January-April. The highest catches of S. *serrata* were recorded in July (95.51 kg/haul/100 m-net). There appeared to be an inverse relationship between the catch rates of *S. serrata* and *P. pelagicus*, although overall *S. serrata* catch rates appeared higher.

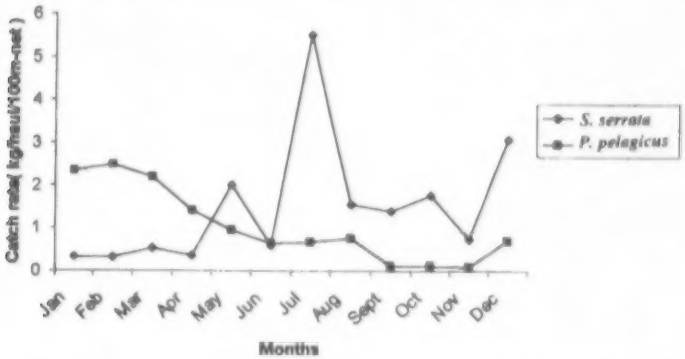


Figure 2. Monthly catch rates of *P. pelagicus* and *S. serrata* for Mzinga Creek during 1995 (standardized for nets of 100 m)

Both species of crabs exhibited two seasonal peaks in maturation. The highest percentage of mature *P. pelagicus* was observed in the February-March interval while the second peak was observed July-November. The first peak for *S. serrata* was in April while the second was July-December, with minor fluctuations. We observed a high proportion of juvenile crabs for both species from January to June (Figs. 3 and 4).

DISCUSSION

The methods used to catch crabs in Mzinga Creek have both advantages and disadvantages. The beach seine is the most popular gear because it provides the highest catch rates. But, it also harvests juvenile crabs that are discarded at the beach where the catch is hauled. Thus, seine fishing could lead to both growth and recruitment overfishing (Figs. 3 and 4). The other methods, which include

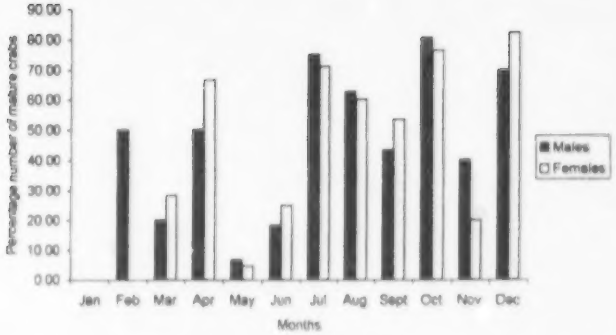


Figure 3. Montly percentage distribution of mature males and females of *S. serrata* for Mzinga Creek during 1995

hand picking and the use of hooked sticks or metal rods, are more selective and therefore have less impact on the resource. Fishers only select crabs of marketable size. The undersized crabs are returned to the water when caught. Unfortunately these methods provide lower catch rates and therefore less income.

Crab catch rates were low throughout the study period. The low catch rates of *S. serrata* January-June could be due to the high proportion of juveniles that dominated the catch (Fig. 3). The low catch rates August-November could be the result of migratory spawning behaviour as they move to the ocean.

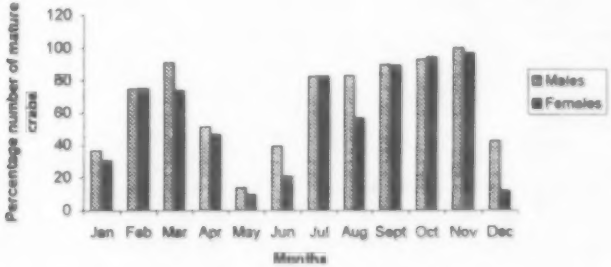


Figure 4. Monthly percentage distribution of mature males and females of *P. pelagicus* for Mzinga Creek during 1995

The low catch rates of *P. pelagicus* in July-December, the period when many were mature (Fig. 4), could also result from a breeding migration. Ovigerous females prefer a sandy substratum for ease in preparing a burrow to incubate the

eggs (Potter *et al.* 1983). They may migrate to the sea for more suitable substrate. The low catch rates May-June could be due to the high proportion of juvenile crabs that dominate the catch (Fig. 4). In addition to the migratory behaviour, the low catch rates of the two crab species could also be attributed to the high fishing pressure from the beach seine fishery.

The inverse catch rate relationship of the two crab species could be related to their feeding habits. Although they tend to feed on the same resources, which include molluscs, crustacea, and fish (Bashemererwa 1981, Patel *et al.* 1979), *S. serrata* grows to a larger size than *P. pelagicus*, and possibly preys on the latter. *P. pelagicus* could be avoiding predation and therefore is only abundant in Mzinga creek when *S. serrata* is absent.

RECOMMENDATIONS

The crab catch rates were generally low albeit with some fluctuations throughout the year. The exploitation of juvenile crabs by beach seines could be a major threat to the crab population. Moreover, the wasteful catch of ovigerous and moulted crabs may have negative effects on the populations. However, with proper management measures, the fishery could be developed to sustainable levels. The following regulatory measures are recommended:

- the use of beach seine nets should be banned in order to protect juvenile crabs and other resources that use the creek as a nursery ground;
- crabs should be harvested using selective gears, which include hand picking, hooked sticks or metal rods, traps and bottom set gillnets of appropriate mesh sizes;
- retention of juvenile, recently moulted (soft-shelled) and ovigerous crabs should be prohibited and they should be returned to the water immediately.

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The octopus fishery in Matemwe and Mkokotoni, Zanzibar

Hassan Mhitu and Narriman S. Jiddawi

INTRODUCTION

Fish are very important to the people of Unguja Island in that many of them directly or indirectly depend on fisheries for their living. Seven fish groups dominate the landings. Demersal fish are the most important, followed in order of importance by the small pelagic species, large pelagic species, shark and ray, octopus and squid, and lobster (Fig. 1).

Octopus and squid are within class Cephalopoda, phylum Mollusca. Cephalopoda are considered the most advanced class within Mollusca. Highly adapted for a swimming existence, they are represented by about 150 genera and 660 species (Worms 1983). They are important not only as a food resource but also have been widely used as experimental subjects in general scientific investigations in such fields as physiology (Ngoile 1987).

Squid, cuttlefishes, and octopus contributed over 3,000,000 t world wide in 1996 (FAO) of which Octopodidae contributed 313,000 t (FAO 1966). In Unguja Island, octopus and squid contribute about 7% to the total fish landings (Fig. 1). Most of the octopus and squid are landed in North A district (Fig. 2). Four species, *Octopus aegina, O. cyaneus, O. macropus* and *O. vulgaris*, are reported to comprise catches in Unguja Island (Bianchi 1985). We observed that *O. vulgaris* dominated the landings.

However, government statistics indicate a decline in landings in recent years from 322 t in 1991 to 240 t in 1996 (Fig. 3). The decline of the resource may be due to lack of proper management strategies. They may have failed to sufficiently counteract the increased demand incurred by the expansion of the tourist industry in the island and the export of octopus to Kenya.

As part of the Institute of Marine Sciences (I.M.S.) and Canadian International Development Agency (C.I.D.A.) fisheries study in Zanzibar, we recorded the artisanal landings in the villages of Matemwe and Mkokotoni, Zanzibar (Jiddawi and Stanley 1999). In this paper, we summarise the information on octopus landings that was gathered in this study.

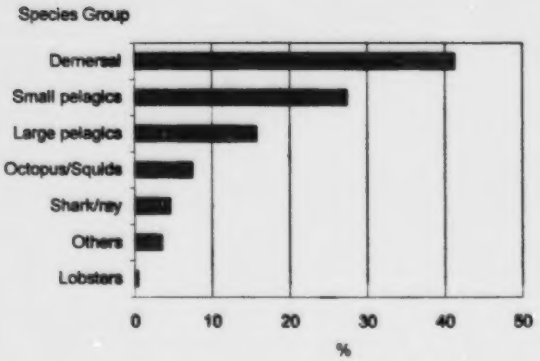

Figure 1. Catch proportions in Unguja Island fishery (1991-1996)

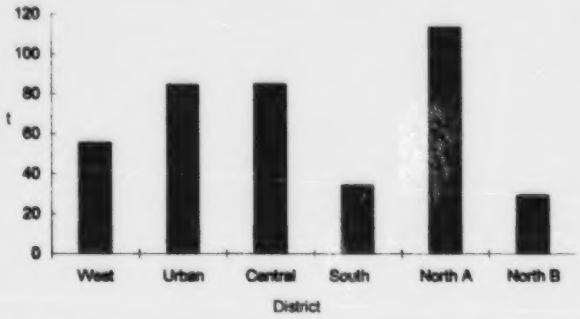

Figure 2. Distributio. of squid and octopus catches by District in Unguja Island

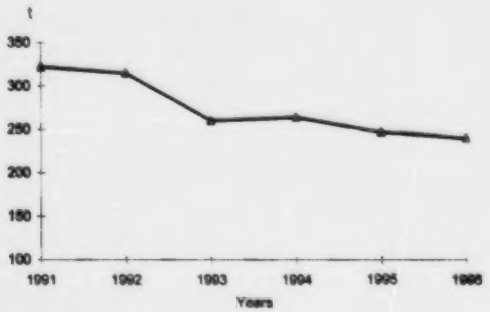

Figure 3. Octopus landings in Unguja Island

METHODS

Landings data were collected at the landing site of Matemwe and Mkokotoni fishing villages March 1995 - March 1997. Total weight and numbers of octopus were recorded for every landing. We also recorded the vessel type used for transportation to the fishing grounds or whether they walked on foot to the reef crest. Men and woman participate in octopus fishing in Mkokotoni, but only men collect octopus in Matemwe. They use pointed sticks (*kijiti*) to gather octopus on foot around coral reefs during low tide. Some are also collected during spearfishing (*mkuki*). We did not distinguish between the two gears.

RESULTS

We sampled 69 and 45 days in Matemwe and Mkokotoni respectively over the two years. Of the 4,221 landings observed, 1,125 (27%) contained octopus (Table 1).

Table 1. Octopus landings (%) in Matemwe and Mkokotoni (April 1995-March 1997)

Proportion of octopus by weight		Proportion of landings with octopus	
Matemwe	Mkoktoni	Matemwe	Mkoktoni
22%	4%	40%	12%

Higher landings of octopus were observed on days close to the new moon and old moon for each month. The effect was more obvious in Matemwe owing to the larger overall landings of octopus (Fig. 4). We also noticed, as with all landings, that octopus landings were lower on Fridays, the day of prayer, and during bad weather days. Too few observations were available to examine seasonal effects but official statistics indicate that landings per day tend to be higher later in the year (Fig. 5).

Catch rate observations were only available from Year 2 of the Matemwe observations and reflect catch of all species by stick and spear fishing. However, the dominant species in this fishery was octopus; thus catch rates by this gear class effectively reflect catch rates of octopus. Although total landings of octopus were higher during spring tides, catch rates showed no relationship with lunar day (Fig. 6).

Mean catch rate for the stick/spear geartype was 11.5 kg per vessel landing. Mean catch/fisherman was 3.9 kg, and the overall catch rate was 0.6-1.3 kg/fisher-hour.

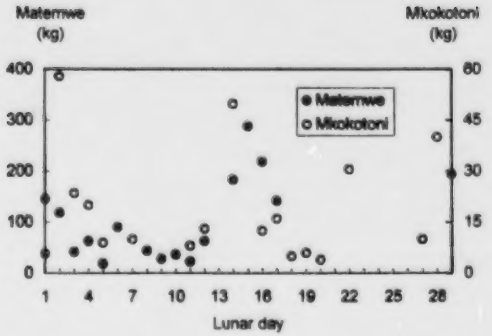

Figure 4. Average daily landings of octopus by lunar day in Matemwe auction site

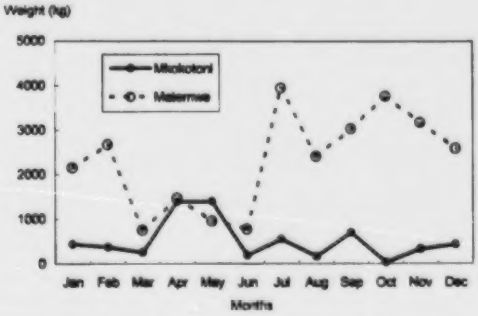

Figure 5. Mean landings of octopus in Unguja Island (Official Statistics)

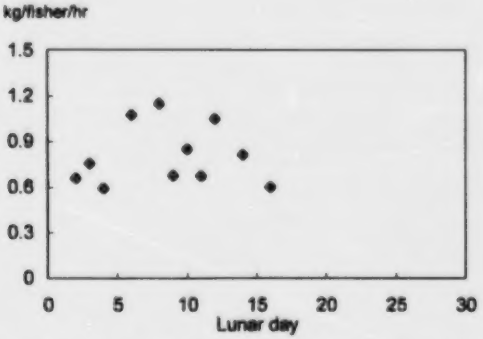

Figure 6. Catch rate of octopus for stick/spear gear type in Matemwe, April 1996-March 1997

A total 8,349 specimens were counted in 960 landings over the two years. For a few landings it was not possible to count the octopus although they were weighed. These observations are omitted from this discussion of average size (Table 2).

Table 2. Number of observations, total weight (kg) and mean weight (kg) for octopus observed in Matemwe and Mkokotoni, April 1995 - March 1997.

	No. landings	No. counted	Total weight	Mean weight (1)	Mean weight (2)
Matemwe	744	7,314	5,374	0.73	0.95
Mkokotoni	216	1,125	731	1.54	1.75

Mean size (1) is calculated from the sum of weight divided by all octopus counted:

$$\overline{W}_i(1) = \sum w_{i,j} / \sum n_{i,j}, \qquad (1)$$

where

$\overline{W}_i$ = mean overall weight for village i,

$\sum w_{i,j}$ = sum of all weights observed for village i and all landing j,

$\sum n_{i,j}$ = sum of counts for each village and all landings.

Formula 1 implicitly weights the observations such that landings of greater number or weight have more influence on the grand mean. If we statistically weight all observations equally such that a landing of 1 kg carries equal importance as a landing of 25 kg:

$$\overline{W}_i(2) = \sum (w_{i,j} / n_{i,j}) / \sum N_{i,j}, \qquad (2)$$

where

$\sum N_{i,j}$ = total of all observations,

the grand mean is larger. This indicates that large landings, by number or weight, tend to have a slightly smaller mean size of octopus. This may result from combining the landings of those octopus caught with a stick on the reef crest with those captured by speargun while diving to greater depths. We noted that the individual landings from spearfishing tend to have fewer but larger specimens.

Mean size and the lunar cycle

Mean size (Formula #1) showed a slight indication to be higher during neap tides (days 4-12, 19-25) in Matemwe (Fig. 7). The relative proportion of landings by spearfishing may increase during neap tides because tides are not low enough to fish the reef crest on foot by stick. No effect was seen in Mkokotoni (Fig. 8).

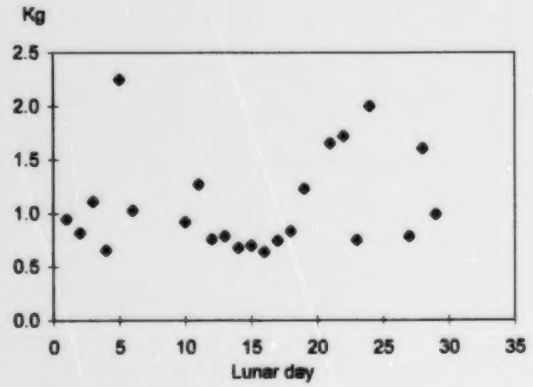

Figure 7. Mean size of octopus by lunar day for Matemwe, April 1996-March 1997

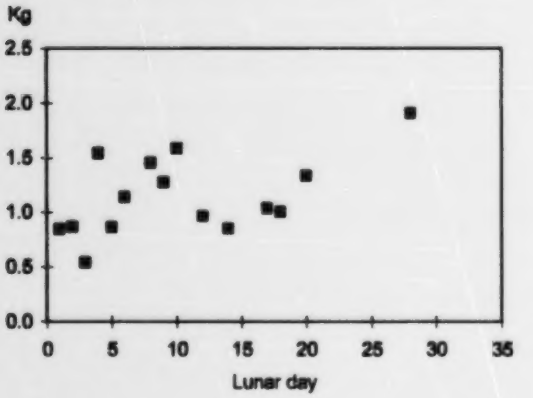

Figure 8. Mean size of octopus by lunar day for Mkokotoni, April 1996-March 1997

No consistent trend in mean size (Formula #1) was observed with season in either village (Fig. 9). Mkokotoni mean weights show increased size late in the calendar year, but these observations were based on few landings.

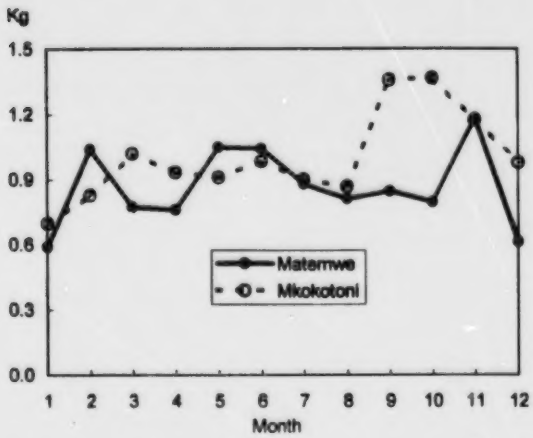

Figure 9. Mean size of octopus by month for Matemwe and Mkokotoni, April 1996-March 1997

RECOMMENDATION

While the importance of octopus to the people of Zanzibar is obvious from general landing statistics, the landed amount probably under-represents the value of octopus to the fisherfolk. It is especially important because it is a resource that is consistent whereas the fish populations are more dynamic. It also is important because it is often used as bait, and is an important part of village festivities. Finally, it is also becoming a staple part of the restaurant menus in the rapidly developing tourist trade of Zanzibar.

While its importance is unquestioned, little is known about the resource and, in particular, its productivity. We recommend that this valuable resource be given the attention that it warrants. With this study, we hope that we have added to the knowledge of this species, shown some interesting areas for investigation and provided some baseline estimates on catch rates and mean size which can be re-visited.

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The artisanal fishery in Bagamoyo: A case study of Mbegani waters

George Msumi, Yunus Mgaya, Masuud Muruke and Adelaide Semesi

INTRODUCTION

Bagamoyo District, in the Coast Region of Tanzania, has a population of about 200,000 with an annual growth rate of 2.5% (Fig. 1). The District has 6 divisions, subdivided into 16 wards with a total number of 78 villages. As in most of the coastal zone, human activities in Bagamoyo are varied. However, the dominant activities are fishing, agriculture and forestry. The District also benefits from tourism and transport.

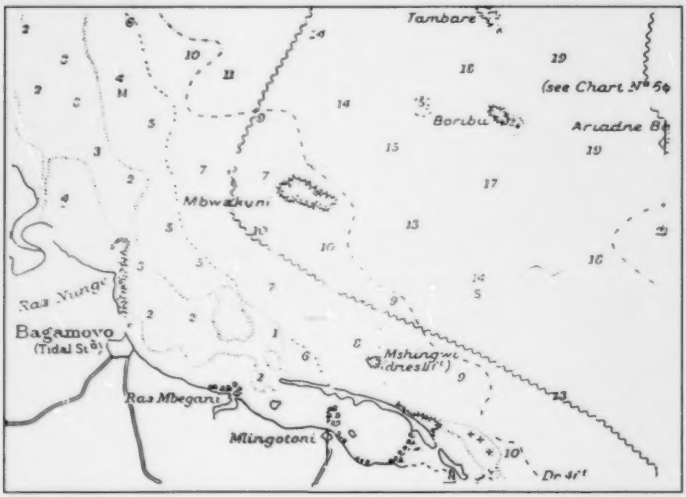

Figure 1. Map of Bagamoyo area

The fishing is mainly artisanal with small vessels and simple gear such as hook-and-line, nets and traps. The 1996 District fisheries statistics indicated that about 1,100 artisanal fishers are active in the District. They land approximately 2,850 t/year of a wide variety of marine fish. Landing sites are scattered along the 60 km coastline and include Buyuni, Sadani, River Wami Camp, Manyema, Kitame, River Ruvu Camp, Bagamoyo Town, Kaole, Mbegani, Mlingotini, Kondo, and Changwahela in the extreme south. The traditional vessels and gears number about 120 and 12,385, respectively. There are about 10 trawlers operating for

prawns and finfish in the coastal waters of Bagamoyo. In some seasons, the artisanal and industrial vessels fish the same grounds but do not necessary catch the same species mix.

The Bagamoyo coastline has a broad continental shelf that extends towards Unguja Island. Sandy/muddy tidal flats, mangroves, coral reefs, rocky intertidal platforms, seagrass and algal beds, lagoons and estuaries characterize the nearshore areas. These support fisheries through their high primary productivity and varied habitat. The majority of the fishers depend on these shallow water habitats for their livelihood. The sea is warm (25-30°C) and the salinity almost constant (34-35‰) with the exception of the estuarine areas. Like other Tanzania coastal areas, Bagamoyo is influenced by two major seasonal airstreams. The NE winds (*Kaskazi*) from December to April are warm and weak, whereas the SE winds (*Kusi*) from June to October are cooler and stronger. Two periods of rain (*Masika* and *Vuli*) occur during the transition between the monsoons.

In spite of the importance of the marine and estuarine resources of Bagamoyo District, resource productivity is being threatened by human activities. The depletion of mangrove forest in the Bagamoyo area for firewood, building poles and salt works as well as the damage to coral reefs caused by dynamite fishing, are major concerns.

The artisanal fishery

Traditional fishing for subsistence or local markets predominates in Bagamoyo areas. It is limited mostly to the sheltered waters of lagoons, estuaries, bays, coral reefs and island lees. Typical vessels include dugout canoes and planked construction boats that are poled, paddled or sailed to local fishing areas. The fishing gear, like the fishing vessels, is always simple and includes weirs, basket traps, nets and, most commonly, handlines.

In spite of the primitive methods of catching, processing and marketing, the artisanal fishery provides over 90% of the fish protein for Bagamoyo's population. It is, therefore, important to obtain a thorough understanding of the exploitation patterns through harvest monitoring. This information provides the baseline information vital for rational management especially at this time when there is a growing disparity between human population and food availability. To gain more insight about the traditional fishery resources, qualitative and quantitative studies have to be conducted to collect more "fine-scale" details on the fishery. Consistent with this philosophy, in January 1997 we started a three-month field monitoring of artisanal finfish landings at Mbegani.

Mbegani is the main landing site within the shores of the nearby bay. It serves Pande and Zinga villages. Fishing and its related activities are of great

importance to the local villages. Limited agricultural opportunities make the sea the main source of household income, employment and animal protein. The fishery in the bay and its vicinity is exclusively artisanal using locally constructed vessels and fishing gear. Most of the fish landed at Mbegani is sent to Dar es Salaam for resale. The objective of the case study was to assess the current status of the marine artisanal finfish fisheries of Bagamoyo District. The landings at Mbegani were studied daily to examine the level of utilization.

METHODS

Details of each boat's landings at Mbegani beach were recorded on specific forms. Data captured included date, type of fishery, landing site, number of fishers, boat type, gear type, total catch, number of fish, site fished, fishing duration, list of species, and the total weight of the catch when possible. Fish were identified following Bianchi (1985) and Fischer and Bianchi (1984). Additional information was obtained by interviewing the fishers. This included price and comments about problems in the fishery. Main fish markets near Mbegani and Pande village were visited to ascertain processing, distribution and marketing patterns.

RESULTS

We observed a variety of fishing gears. Handlines (*mshipi*) were the most popular fishing gear in the Bagamoyo region, especially in Mbegani where about 70% of the fishers use the gear. There are 105 handline fishers in Pande village although the actual number of fishers using the nearby grounds is larger owing to additional visiting fishers from Zanzibar, Bagamoyo, Kaole and Mlingotini. The preferred bait is a sipunculid worm. Favoured fishing grounds are near mangrove forests and coral reefs. The baited lines are often trolled behind a moving boat. The number of lines in each boat is a function of the number of fishers onboard. The size of the hooks depends on the size of the targeted fish.

Large beach seines (*juya*) are the second most popular gear. These are deployed over seagrass beds and sometimes, albeit destructively, over coral reefs. Teams of fishers haul them over shallow water. Strong swimmers try to prevent fishes from escaping the net during hauling by splashing and making calls like seagulls. Two persons can operate the smallest seine; the largest requires about 20. Only three large seine nets (250-300 m long with a mesh size 1-1.5 in) have been recorded during the monitoring of landings at Mbegani. About 10 large seine nets are known to operate in Kaole and Mlingotini waters.

Basket traps (*madema*) are hexagonal in shape and made of bamboo. They are weighted with pieces of rock and usually set near coral reefs. Larger ones may

be set in deeper waters. They are baited with algae, chunks of squid, octopus or crabs. Three vessels use traps.

Various gillnets (*jarife*) are also used. Small mesh nets are set either at the bottom or on the surface near coral outcrops, off the edge of coral reefs or near river mouths. Large mesh nets for larger fish are set offshore and allowed to drift overnight. These nets are most effective on moonless or cloudy nights. Only two vessels were reported to use these nets. Both vessels were motorized.

Weirs (*uzio*) are made of long rows of stakes stretching from the beach slope across the sandy/muddy tidal flats to the low-tide level with an enclosure at the end. The fish are trapped as they try to swim back to sea with the ebbing tide. There are two weirs near Mbegani.

Other gears included three cast nets (*kimia*) and blastfishing. Although illegal, blastfishing is used near coral reefs and in open water when fishers locate schooling pelagic fish. The stunned or killed fish are scooped with hand-nets. In addition to killing many additional fish, the explosions destroy the coral reefs and thus the habitat. More than five vessels from the neighbouring villages of Mlingotini and Kondo practice this destructive fishery.

Fishing Crafts

Artisanal fishers in Bagamoyo mostly use traditional fishing vessels. Dugout canoes (*ngalawa*) with outriggers are the most numerous. They vary in length from 3-6 meters and usually carry 1-3 fishers. There are approximately 16 in the landing site but only 8-10 have been recorded going fishing on any 1 day. Few dugout canoes fish during bad weather.

Planked construction dhows (*dau*) are pointed at both ends and 4-6 m in length. They provide a larger working platform, but are more expensive to maintain. Dhows are the second most common vessel and are used primarily for beach seining. Five dhows were noted landing their catches at Mbegani. Others were known to land their catches in Mlingotini and Kaole although they are known to be operating in the vicinity of Mbegani.

Mashua are larger planked construction boats 6-10 m in length with a transom stern. They are more popular at Custom and Nchipana landing beaches of Bagamoyo. Only two have been observed to operate in Mbegani waters. Dugout canoes without outriggers (*mtumbwi*) are used in sheltered inshore waters of lagoons and bays. Five have been recorded at Mbegani landing site.

A *hori* is also a locally made wooden boat of modern design, 2-6 m in length. It is flat-bottomed and considered to be more seaworthy than others and is used

further offshore. These boats rarely landed their catches at Mbegani. All the above vessels and crafts may be propelled by paddles, punting-poles or by lateen sails. Very few are motorized.

Fishing Grounds

Most fishing is conducted in nearshore grounds that are easily accessible and safe during inclement weather. Some men and women fish on foot to collect molluscs, crabs, and other small crustaceans (*uduvi*) among mangroves and shallow water. The rich offshore grounds are exploited less often and only during calm weather. Mbegani lagoon, Chambani, Kaole, Mshingwi and Changwahela are within 5 km of Mbegani landing site and thus receive more fishing pressure. Mwambakuni and Chumbe, being more distant (12 km), receive less fishing pressure. The average time spent in one fishing trip depends on the distance to the fishing ground. For grounds close to the landing site, the trips took less than six hours unless night fishing. For the distant and richer grounds, the duration was 8-10 hours.

Catch Composition

The landings comprised numerous species (Table 1). Fish large enough for human consumption are usually long-lived predators high in the food chain. These are the main targets of the traditional fishery that fishes near hard bottom.

Catch Rates

The mean daily catch rates per landing varied with gear, area, time of day, vessels, trip duration, weather and season. Catch rates for hand-lines ranged from 5-60 kg/boat with a mean of 50 kg. The majority of the fishers (70%) use this gear and their catches were easily monitored as opposed to other gears that operated sporadically.

Table 1. Major components of the landings at Mbegani landing site

Family name	Common name	Swahili name	%
Lutjanidae	snapper	*Kelea*	40
Lethrinidae	emperor	*Changu*	34
Nemipteridae	bream	*Koana*	11
Carangidae	trevally	*Kolekole*	5
Belonidae	needlefish	*Mikule*	3
Teraponidae	terapon	*Kui*	2
Haemulidae	sweetlips	*Komba*	2
Ariidae	catfish	*Hongwe*	2
Haemulidae	grunter	*Fuatundu*	<1
Mixed	shark	*Papa*	<1
Mixed	ray	*Taa*	<1
Sphyrnidae	barracuda	*Mizia*	<1
Scombridae	queenfish	*Pandu*	<1
Mullidae	goatfish	*Mkundaji*	<1

The dhow daily catches were always higher than those of the dugout-outrigger vessels, and catches from distant fishing grounds tended to be higher than those from nearer grounds. The catch per unit effort (CPUE) also followed a similar trend in that it tended to increase towards the months of March and April (Table 2).

Table 2. Weekly artisanal fishing data, Mbegani landing beach, Mshingwi fishing ground (bait was squid or sipunculid worms) (catch in kg).

Month:	Feb	Feb	Feb	Feb	Mar	Mar	Mar	Mar	Apr	Apr	Apr	Apr
Week	1	2	3	4	6	5	7	8	9	10	11	12
Vessels/day	5	8	7	9	7	8	7	8	9	6	8	9
Fishers/day	9	17	13	19	18	14	22	23	18	14	18	22
Fishers/vessel	2	2	2	2	3	2	3	3	2	2	3	3
Catch/day	48	88	52	74	58	48	61	69	95	60	70	132
Catch/vessel/day	9.6	11.0	7.4	8.2	8.0	6.0	8.7	8.6	10.6	10.0	8.8	14.7
Hours/day	9	9	8	9	9	9	9	8	10	9	9	9
CPUE (kg/hr)	1.2	1.2	1.0	1.0	0.8	0.6	1.0	1.0	1.0	1.0	1.0	1.6
Handlines/vessel	2	2	2	2	3	2	3	3	2	2	3	3
Sales (TSh 000s)	-	-	-	315	205	217	245	202	429	248	307	540

Monthly total catches and sales

While the time series is not long enough to examine trends they do provide some useful insights on the resources exploited by Mbegani fishers. Monthly total landings and sales showed an upward trend probably because fish became more available during the rainy season caused by the prevailing NE winds of the northern monsoon (Table 3). It should also be noted that the actual total sales value is probably underestimated. All fish is sold to fishmongers and transported by trucks to Dar es Salaam where the fish price is higher owing to greater demand and the purchasing power of city residents.

Table 3. Monthly total catches and sales of the artisanal fishery

1997	Total Landings (kg)	Total Sales (TSh)
February	1,884	314,850 (1 week)
March	1,646	868,900 (4 weeks)
April	2,505	1,521,110 (4 weeks)

DISCUSSION

Fishing Gears and Crafts

The conventional fishing practices in the artisanal fishery cause little damage to the marine habitat; thus there is potential for sustainable utilization. However, localized overfishing of specific stocks is fairly common, as is the use of destructive fishing practices, predominantly by visiting fishers. The declining catches are reducing income and protein supply. Fishers use destructive gears such as small-meshed beach seines and blastfishing partly because they are unaware of the destructive impacts. Such practices might be reduced by raising community awareness about the relationship between the environment and resource productivity and the impacts of overfishing and destructive harvesting on the environment. They also use these destructive methods because of the higher costs of conventional fishing equipment.

The obstacles to improving traditional fishing equipment and techniques include the roughness of coral bottom, strong currents which can result in the loss of gear, patchy distribution of fish, and the relatively high costs of mechanization in an area of inexpensive labour.

Fishing Grounds

The shortage of gear and the lack of motorized vessels limit the fishing range; thus most fishing is concentrated in shallow waters close to shore near the environmentally sensitive coral reefs, seagrass beds and mangrove forests. The nearshore marine environment has, therefore, been overfished and degraded. Sustainable development of artisanal fisheries should include the protection of these habitats. They habitats are linked, interdependant and form one large open system. Furthermore, the existing conflict between industrial and artisanal fishers should be resolved. Industrial fishing activities have encroached onto traditional fishing grounds. The increased fishing pressure is leading to stock depletion of the nearshore fishing grounds. Measures should be taken to divert pressure to the more distant fishing grounds.

While the number of species exploited by local fishers remains high, the effects of exploitation are obvious from the declining number of large specimens. Monitoring of fish landings is valuable for detecting these subtle indicators of overfishing. Species composition information over time also can be used for detecting changes in the zoogeographical ranges, which, in turn, can indicate environmental or ecological change owing to fishing. Increased knowledge of marine species from studies of the fishery provides a basis for formulating effective management policy.

RECOMMENDATIONS

On the basis of our study of the artisanal fishery of Bagamoyo, we make the following recommendations:

- there should be a defined national policy specific for the protection, conservation and restoration of marine and coastal habitats and the species present in these habitats (the present policy is too general to protect the critical habitats and species);
- the catch assessment survey (CAS) statistical method, which was introduced by FAO and is currently being used by the Fisheries Department, should be strengthened and expanded to cover more landing sites;
- more research should be conducted to find levels of usage that will not result in the over-utilization of particular resources;
- increased community awareness should be developed through expanded extension services and focus on effects of overfishing and destructive harvesting methods;
- extension training should concentrate on integrating community participation into fishery management;
- fishing gear and boat equipment should be made available at reasonable prices to encourage fishers to improve their fishing practices and to increase their range of operation;
- a campaign should be initiated to promote sustainable fishing practices with a long-term goal of restoring the balance of nature;
- access to credit for small-scale fishers should be improved to enable them to acquire more reliable fishing equipment and more seaworthy vessels;
- fisheries regulations should be strengthened and enforcement should be improved by providing facilities such as patrol boats and armed officers in order to deter illegal fishing.

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The status of the shark fishery in Zanzibar, East Africa: A case study

Narriman S. Jiddawi and Mussa A. Shehe

INTRODUCTION

The rich marine resources of Zanzibar are essential to the socio-economic welfare of the population. The fishing industry, which is 90% artisanal, is one of the most important occupations for the coastal people. It directly employs more than 15,000 people and provides employment to many others through supporting activities such as boat building, gear manufacture and fish trading (Sanders 1990). While these fisheries may only represent 4-10% of the overall economy, or GDP (Haji 1990), the fisheries component remains the major source of protein by providing for an annual consumption of about 20 kg/person.

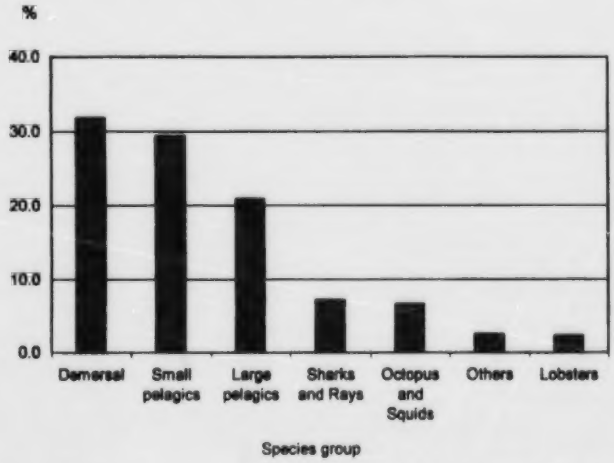

Figure 1. Mean percent composition of fishery landings in Zanzibar (1989-1995)

Although the principal groups of fish in the landings remain demersal coral reef and small pelagic fish, shark and ray species are also important and contribute over 4.5 and 2.5% of the landings, respectively (Fig. 1). The conservation and management of these cartilaginous fishes, especially sharks, is becoming increasingly important. The increased attention is partly related to the recognition of the plight of shark species worldwide. Once considered under-utilized, an increasing number of shark populations face over-exploitation and depletion as markets for shark meat, fins, and cartilage expand (Shark News

1995). Sharks are vulnerable to overfishing because of their slow growth, late maturity, and low reproductive capacity. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (C.I.T.E.S.) suggested that sharks are potentially vulnerable to extinction (Shark News 1996). This paper summarizes the characteristics of the shark fisheries of Zanzibar. We identify the economically important and threatened species, summarize yearly and seasonal trends in landings, describe the shark trade, and characterise the current management regime.

METHODS

Information for this report was gathered from interviews, publications, and direct observations. Structured interviews were conducted with fishers, exporters, consumers and government officials. Additional data were obtained from the Fisheries Statistics section of the Sub Commission of Fisheries (S.C.F.), Zanzibar, and from a study of 2 landing stations in Zanzibar by the Institute of Marine Sciences (Jiddawi and Stanley 1999).

RESULTS

Official statistics indicate that annual fish landings in Zanzibar have declined from about 20,000 t in the 1980s to about 10,000 t by the early 1990s (Jiddawi *et al.* 1992). Yearly landings of shark and ray appear have fluctuated from 100-300 t with an anomalous peak of almost 1,000 t in 1994 (Fig. 2). Landings have declined since 1994. While shark are caught year-round, official data indicate peak landings in April, July and October (Fig. 3). Up to 2.2 t of shark fins are exported annually (Fig. 4). However, landings have been much lower in recent years with exports of only 0.3 t in 1995. The central district of Unguja Island, followed by the North A district provides the most landings (Fig. 5).

In a study of 2 villages in the northern districts, Matemwe and Mkokotoni, annual artisanal fish landings of shark and rays landings were estimated to be 6.0 and 0.25 t, respectively (unpublished data).

Interviews

The most common species according to fishers were angel sharks (Table 1). Their ranking indicated that four species were rare (rank=23). Fishers state that the catches have declined. They often only see one shark landing each day in a landing site, unlike previous times when many landings might be observed. They explain the sharp decrease to overfishing caused in turn by the increased number of fishers and the application of poor fishing methods. Small individuals are often captured as bycatch while targeting on other species. This catch of small, sexually immature specimens further reduces the stock productivity.

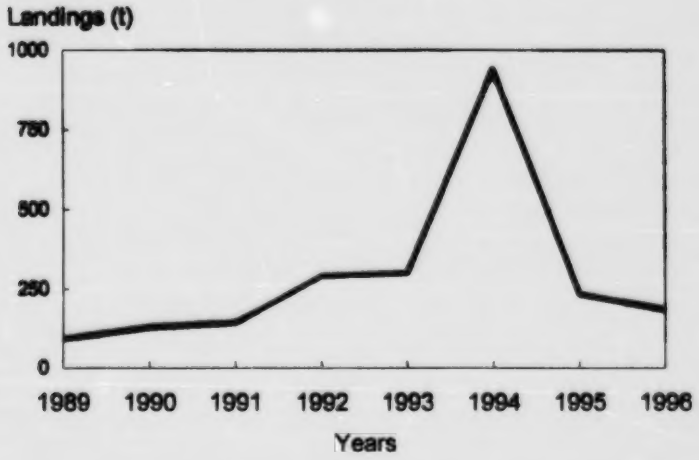

Figure 2. Total tonnage of shark and ray landed in Zanzibar, 1989-1995

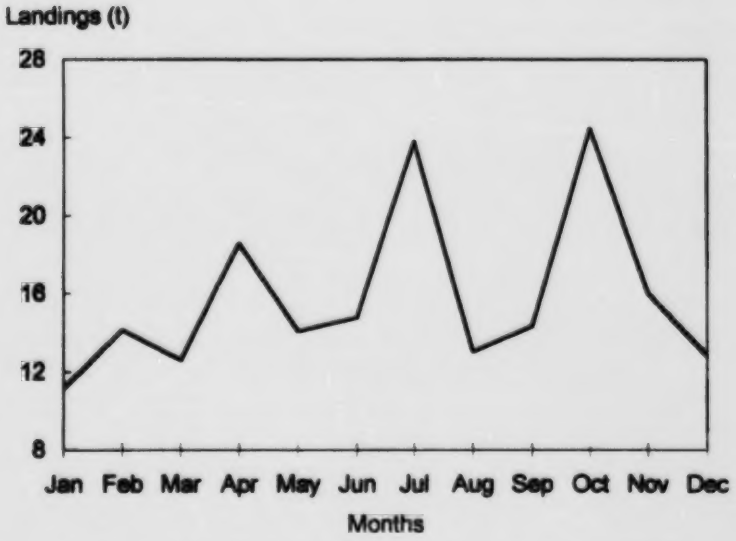

Figure 3. Mean monthly landings of shark and ray from selected regions of Zanzibar (1995-1996)

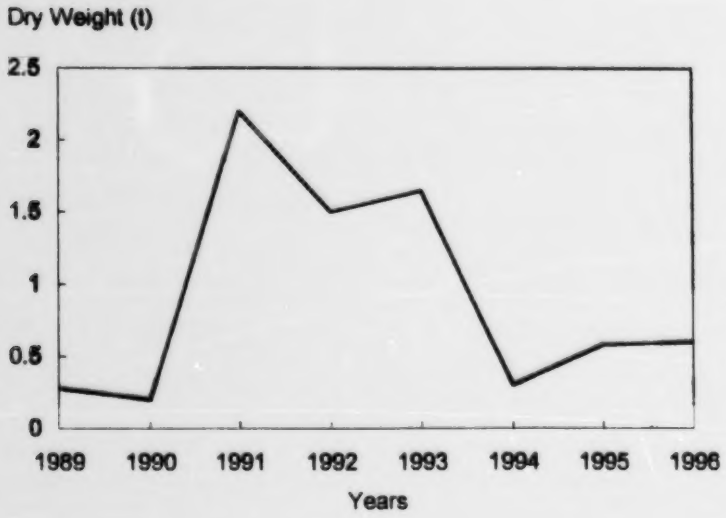

Figure 4. Annual export of shark fins

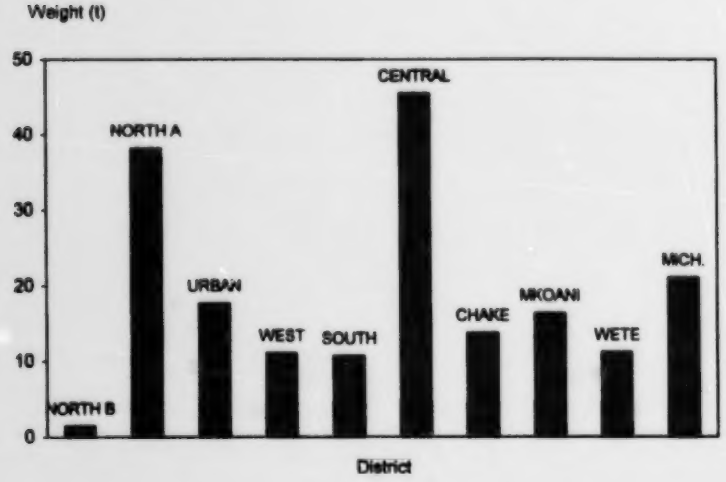

Figure 5. Total tonnage of shark caught by District in Zanzibar

Species name	English name	Local name	%	Rank	Fisher Remarks
1. *Carcharhinus falciformis*	Silky shark	*Dhamirime*	52	10	
2. *Galeocerdo cuvieri*	Tiger shark	*Papa madebe*	76	3	Very dangerous
3. *Carcharhinus albimarginatus*	Silver tip shark	*Sangani or Marimbe*	52	10	
4. *Carcharhinus melanopturus*	Black tip reef shark	*Papa*	40	18	
5. *Carcharhinus sealei*	Black spot shark	*Mambwe*	52	10	
6. *Carcharhinus wheeler*	Black tail reef shark	*Mambwe*	32	22	
7. *Carcharhinus macloti*	Hardnose shark	*Papa mwamba*	52	10	
8. *Carcharhinus plumbus*	Sandbar shark	*Madebe tumbo*	28	24	Fins-expensive, always caught with pups
9. *Carcharhinus sorrah*	Spot tail shark	*Kinengo mambwe*	48	15	
10. *Loxodon macrorhinus*	Slit eye shark	*Sasareni mtobwe*	56	8	
11. *Negaprion acutidens*	Sicklefin lemon shark	*Papa ngozi*	40	18	
12. *Rhizoprionodon acutus*	Milk shark	*Papa nyama*	48	15	
13. *Scoliodon laticauldus*	Spadenose shark	*Papa sumbwii*	44	17	
14. *Triaenodon obesus*	White tip reef shark	*Papa siruanzi*	28	24	Caught during S.E Monsoon
15. *Ginglymastoma brevicandatum*	Short tail nurse shark	*Papa usingizi or Dovai*	84	2	
16. *Hemipristis elongatus*	Snaggle tooth shark	*Papa mwamba mweupe*	32	22	
17. *Isurus oxyrinchus*	Shortfin mako	*Nyarani*	76	3	
18. *Sphyrna lewini*	Scalloped hammer head	*Papa pingusi*	36	21	Mainly caught in Pemba Channel
19. *Sphyrna mokarran*	Great hammer head	*Papa pingusi*	60	7	Fins expensive, meat more preferred.
20. *Centrophorus uyota*	Little gulper shark	*Joza mbiu*	52	10	Caught during the Northern monsoon
21. *Centrphorus moluccensis*	Small fin gulper shark	*Papa*	28	24	
22. *Delatius licha*	Kiten fin shark	*Papa*	40	18	
23. *Squatina africana*	African angel shark	*Kirimawe*	96	1	Very common, caught with speargun
24. *Stegostoma fasciatum*	Zebra shark	*Papachindi*	76	3	Frequently caught
25. *Hypogaleus zanzibariensis*	Black tip tope or lesser soup fin	*Papa upinde*	56	8	Caught offshore
26. *Alopias vulpinus*	Thresher shark	*Sangani*	28	24	Currently rarely caught

Table 1. Principal shark species in order of occurrence in the landings as reported by fishers

An FAO study of the commercial marine and brackish water species of Tanzania identified 26 species of shark in the landings (Bianchi 1985). However, the report did not reveal how many of the species are commonly found in Zanzibar waters. Our interviews have revealed that all of the 26 species are commonly observed. The most commonly landed species belong to the family Carcharhinidae. The fishers also reported that other species, not indicated in the FAO manual, had been observed. These include the whale shark that they had observed in Zanzibar channel. Using pictures for reference, fishers reported that the most commonly caught species were the African angel shark, the thresher shark, small fin gulper shark and white tip reef shark.

Seasonality

Fishers reported that sharks move from the deep waters to the shallower coastal areas coincident with changes in the monsoon winds. Sharks move to the shallow waters during the northern monsoon then return to the deeper waters during the southern monsoon. Preferred fishing grounds vary with season, but accessibility to these grounds by the small sail-driven artisanal vessels is not always assured. Weather may restrict access to seasonal fishing grounds.

Prices

Shark meat tends to obtain lower prices than the more preferred species such as snapper, grouper, tuna and kingfish. Maximum price per kg for shark rarely exceeds TSh800/kg ($US1.33/kg), while preferred species may cost up to TSh1,300/kg ($US2.17/kg). Coastal people tend to believe that big fish are not as good to eat. Some fishers reported that eating shark led to stomach discomfort. While shark meat is not the preferred food in local markets, shark fins have a reliable demand in eastern markets, especially Hongkong. The history of this trade can be traced to 1919 (Last 1929). For example, in 1923 it was reported that about 6.6 t were exported annually as compared with 0.5 t in 1996.

DISCUSSION

The Zanzibar government is taking an increasingly active and positive role in the conservation and management of marine resources. This is reflected in the revision of fisheries legislation to improve the legal basis for marine resource conservation. For instance, all forms of destructive fishing methods, such as blastfishing, capture of undersized fish, use of poison in fishing operations and destruction of marine habitat is prohibited. In addition, Zanzibar has taken several steps towards establishment of marine protected areas and community based management. The aim is to comply with Chapter 17, Sections 1c and 1d of the United Nations Conference on Environment and Development. In spite of these developments, however, fishing continues at what may be unsustainable

levels. The sale of the fins of under-sized shark in the Zanzibar central market is indicative of the problem.

RECOMMENDATIONS

The current decline in shark landings indicates that prompt action is required to maintain the productivity of these stocks of Zanzibar. We recommend the following steps to preserve this valuable resource:

- educate the public on the biology and fisheries of sharks as well as the ecological and economic significance of sharks;
- encourage the development of local conservation and management strategies such as the successful precedent of Fumba village;
- provide resources to local authorities so that they may assume a bigger management role;
- augment fisheries administrations with sufficient analytical and technical capabilities;
- increase transparency on issues pertaining to marine environment and fishery resources in order to make people aware of the dangers linked to resource degradation and enable them to participate more fully in decision-making on resource conservation and management;
- develop strategies for shark fishery management and conduct more research on sharks and other cartilaginous fishes in Zanzibar;
- improve data collection about shark landings;
- improve enforcement of fisheries laws.

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Data collected by fishers provide insight into the fishery for large pelagic species in the southern Pemba Channel

Matthew D. Richmond

INTRODUCTION

Along the East Coast of Unguja Island, Zanzibar, Tanzania, there are about 18 small village groups, each with 2,000-5,000 inhabitants. Each of these villages rely, to varying degrees, on the shallow lagoon, fringing coral reef, adjacent seas and coral-rag coastal land for its livelihood. However, little is known about how each of the activities contributes to the prosperity of each village. This information is essential for developing effective management plans that consider interests of both the villagers and commercial developments in this area. In particular, village interests must be coordinated with tourism development, which has strong Government encouragement.

Principal activities along the east coast of Unguja Island include:

- seaweed farming - began 1990 in the southeast, now present along entire east coast;
- mangrove pole cutting - only around Chwaka Bay (central east coast);
- intertidal collecting - mainly for molluscs, sea cucumbers and octopus;
- lagoon and shallow water netting and spearfishing - small fish, lobster, octopus;
- reef hook and line fishing and spearfishing - reef fish;
- reef basket-trap fishing - reef fish;
- reef base netting/hook-line fishing - large demersal fish such as grouper, shark;
- open-water gill-netting (mostly northern Unguja) - large pelagic fish such as tuna;
- coral-rag agriculture and animal husbandry - basic crops and goats;
- tourism - minor prior to 1990; rapid development since 1993.

Most of the activities listed above are related to fishing. On Zanzibar, the Fisheries Sub Commission of the Ministry of Natural Resources collates landings data, based on regular monitoring at selected fish-landing sites around Unguja Island. These data include total monthly catches, major species composition, numbers and types of vessels and gear used. However, few details are collected on fishing effort, catch by species or revenue of the individual boats or fishers. Furthermore, the data collected by the Fisheries Sub Commission are widely regarded as lacking in precision and of limited statistical value. An

opportunity for a detailed investigation arose with the introduction of the open-water gillnetting for large pelagic species in Matemwe District. The Royal Netherlands Embassy (DSM) agreed to grant two fishing cooperatives from Kigomani village, Matemwe District (Fig. 1), a total of Tsh3.5 million ($US7,000) each, for the purchase of boats, large-meshed fish nets and outboard engines.

The donation was provided through the Netherlands Embassy Small Project Scheme. The objective was to reduce fishing pressure on the coral reefs by encouraging fishers to fish offshore. The 12-member cooperatives had been operating at subsistence level since their inception, using a single outrigger sailing canoe each, resulting in negligible financial turnover. In order to improve and uplift their economic base, the members concluded that they required larger boats (*mashua* or small dhows), powered by sail and outboard engine and equipped with 6-10 inch mesh gillnets. The target was to fish for large pelagic species in open waters beyond the reef. This form of fishing had, at the time, been conducted for many years by about 40 boats from the north and northwestern villages of Nungwi, Fukuchani and Mkokotoni (Fig. 1), but was new to Kigomani village. On March 29, 1994, HRH Prince Bernhard of the Netherlands was the guest of honour at the handing-over ceremony and inauguration of this Small Embassy Project launching of the fishing vessels *Shukrani* and *Fikirini*.

Following inauguration of the project, Mr. Theo van de Ven, the Netherlands Embassy representative on Zanzibar, approached the Institute of Marine Sciences (I.M.S.) regarding monitoring the effectiveness of the grant. The potential to collect detailed data on the fishing activities of the two vessels was also realized and discussed with the fishers. They were willing to allow their activities to be monitored, partly as a precondition to receiving the grant, and were enthusiastic about being involved themselves in the fisheries data collection. Ensuing discussions with the fishers, I.M.S., the Fisheries Sub Commission and the Department of the Environment led to the design and implementation of The Matemwe Fishing Cooperative Monitoring Programme. The objective was to establish whether the donation was providing economic gain to the cooperatives and consequently, whether this form of aid should be encouraged. The data collection program was designed to collect information regarding:

- weekly fishing patterns;
- fishing grounds;
- fishing methods and duration of effort;
- species composition and catch weights;
- costs, revenues and profits.

Figure 1. Map of main fishing ground for large pelagic fishing species

The first report (Richmond and Mganwa 1994) summarized the preliminary findings. A later paper (Richmond and Mganwa 1995) presented the data after a complete year. The present report summarizes the period of May 1994 - September 1997. It focuses on the financial results and salient features of the catch data collected by crew of the two vessels.

METHODS

For the first two years, fishers recorded the data using a specially designed monthly logbook (Fig. 2). Fish weight was deliberately omitted owing to the extra work and inconvenience it would impose on the fishers. The co-operatives were visited every two weeks to monitor their progress, discuss problems and inspect the daily record forms. Inspection involved counter-checking entries against fish catches and money accrued from fish sales. Account notes and records kept were examined and inconsistencies clarified. At the end of each month, a summary of financial returns was prepared. Each month the logbooks were swapped with ones in which the data had been erased, after being copied into a master record book and entered into a computer spreadsheet.

The use of the logbook ended in February 1996 due to changes in staff at I.M.S. The cooperatives, however, continued to record the catch and financial data in their own record books. One cooperative entered daily species data and sales as per the logbooks, whilst the other cooperative simply recorded sales of the catches.

RESULTS

The daily fishing routine was to leave the home beach in the afternoon with four members aboard, travel north up the lagoon to the opening (*mlangoni*) using the engine and then head into deep water beyond the reef. Distance travelled depended on weather and reliability of the engine at the time. Fishing was usually conducted in the southern end of the Pemba Channel (Fig. 1). The *Shukrani* and *Fikirini* would join the fleet of about 40 similar vessels although many of the other vessels lacked engines. By 1997, the fleet consisted of about 120 vessels. The surface set net, hanging about 8 m deep, was shot over the side prior to sunset. The last length would then be attached to the vessel and together they would drift, mostly northwards, for up to 6 hours through the night. Once or twice a night the nets would be hauled in and catches removed No navigation aids, lights, or radar reflectors were used. The boats returned to shore by sail or motor (depending on wind speed and direction, and fishing location) early in the morning to sell their catches, often at the northern village of Nungwi. Nungwi attracts many more buyers from town; thus prices are higher.

Siku: **(date)**	Saa ya kuondoka **(time:dep.)**	Saa ya kurudi **(time: return)**	Idadi ya wavuvi kutoka chombo **(no. of fishers)**

Sehemu ya uvuvi **(fishing destination code)**	Muda kwa tanga **(time under sail)**	Muda kwa ingini **(time with engine)**	Mafuta yali yotumika **(vol. fuel used)**	Mwandishi **(name of recorder)**

SAMAKI **(fish name)**	no	mtego	hatma	SAMAKI	no	mtego	hatma	SAMAKI	no	mtego	hatma
NDUWARU **(marlin)**				KANADI **(kanadi)**				KANGAJA **(surgeonfish)**			
MBASI **(sailfish)**				NGURU **(kingfish)**				PUJU **(unicorn)**			
SEHEWA **(kawakawa)**				KOLEKOLE **(caranx)**				MZIA **(needlefish)**			
JODARI **(yellowfin)**				SONGORO **(cobia)**				TENGA **(mantaray)**			
ZANUBA **(skipjack)**				PANGE **(dolphinfish)**				PUNGU **(eagleray)**			
JOZA **(wedgefish)**				NYENGA **(stingray)**				MWATIKO MNYIMBI			
KISUKANI **(rainbow r.)**				HADANA **(barracuda)**				SHAZANDA **(snapper)**			
KUNGU **(red snap.)**				MRONGO **(jobfish)**				KINYOZI **(devilray)**			
PANDU ROBO				DAGAA **(sardine)**				TAA **(stingray)**			
ZIZI CHANGU				TASI **(rabbitfish)**				PAPA **(shark)**			
MOLOLE **(snapper)**				UNA (VIBUA) MACHO				NGISI PWEZA			
SIO **(caranx)**				SHENGWA **(flathead)**				ngini **(other)**			
KANDE BUNJU				MBONO **(fusiliers)**				KASA **(turtle)**			
KAMBA KOCHI				CHEWA **(grouper)**				POMBOO **(dolphin)**			

Majina ya mitego: **(fishing method:)**	Hatma **(fate of the fish)**	Jumla ya fedha za mauzo: (total sale value)
N Nyavu **(net)**	M Mauzo **(sold)**	
M Mshipi **(hook/line)**	K Kitoweo **(consumed)**	
D Dema **(trap)**	C Chumvi **(salted)**	
	Sehemu ya mauzo: **(selling destination)**	

Figure 2. Logbook daily recording form for large pelagics

At times, the Kigomani boats would be based at Nungwi, or other villages, for up to 10 days thereafter returning home with their earnings. Catches were only landed at the home beach when weather or engine problems prevented travel to Nungwi.

Activity of the boats followed a lunar pattern with fishing concentrated over the 10-14 consecutive dark nights centered on the night of the new moon. Catches reflected the lunar activity pattern. According to the fishers, the fish stay deeper during bright nights and can see the nets. When catches declined, towards the half moon, the boats would return to Kigomani where nets and vessel were serviced prior to fishing again 12-20 days later.

The logbook data forms were completed by the member of each cooperative responsible for operating the village shop owned by the co-operative. These account keepers were the only members competent at reading and writing in Ki-Swahili. Data entry was consistent and accurate for numbers of fish, species caught, financial return and the day fished, but not date. The other remaining data fields were often incomplete initially although regular visits ensured that many of the missing entries were subsequently filled. Some items such as the number of fishers, time of departure and arrival and method of fishing remained constant throughout the year.

Fishing effort was reduced at times owing to the mechanical problems the fishers encountered with the Ruggerini diesel outboard engines. The engines were generally used for no more than 3 h/day on average yet they required continual technical attention and replacement parts. The latter could not be supplied by ZAFICO (Zanzibar Fishing Corporation) from whom the engines were purchased, albeit at a very competitive price. At times, both engines were out of order for weeks with fishing only taking place for a few days per month when other engines could be used. Because of the need to travel north up the lagoon in order to get out into the open sea, the engines are far more critical to Kigomani fishers. In villages in the north such as Nungwi, boats are capable of sailing in and out on most days. Rough seas and strong winds also contributed to the reduction in fishing effort, especially during parts of the northern monsoon period, November-March.

The vessels caught over 45 species of fish in the first 2 years. Tuna (kawakawa, yellowfin, skipjack and bonito) comprised over 60% of the total number of fish caught (Table 1, Fig. 3). Yellowfin tuna, kawakawa and billfish (sailfish and marlin) were the most valuable species. Catch size and composition varied over the year. The highest and most consistent catches were observed June-October. Mean numbers of yellowfin tuna caught per night for each month was highest in

April 1995, but June was typically the best month over all years (Fig. 4). Fishing effort is often reduced during the wet season, January-June.

Table 1. List of fish species commonly captured in the pelagic fishery

Common name	Swahili name	Latin name
Black marlin	*Nduwaru*	*Makaira indica*
Blue marlin	*Nduwaru*	*Makaira mazara*
Striped marlin	*Nduwaru*	*Tetrapturus audax*
Sailfish	*Mbasi*	*Istiophorus platypterus*
Kawakawa	*Sehewa*	*Euthynnus affinis*
Frigate tuna	*Zanuba*	*Auxis thazard*
Yellowfin tuna	*Jodari*	*Thunnus albacares*
Bigeye tuna	*kirungu*	*Thunnus obesus*
Striped bonito	*salehe*	*Sarda orientalis*
Kingfish/spanish mackerel	*nguru*	*Scomberomorus commersoni*
Kanadi kingfish	*kanadi*	*Scomberomorus guttatus*
Talang queenfish	*pandu robo*	*Scomberoides commersonianus*
Indian mackerel	*vibua*	*Rastrelliger kanagurta*
Bigeye scad	*vibua vibagara*	*Selar crumenophthalmus*
Giant trevally	*karambisi*	*Caranx ignobilis*
Caranx	*kole kole*	*Caranx spp.*
Dolphinfish	*pange*	*Coryphaena hippurus*
Rainbow runner	*kisukari*	*Elegatis bipinnulata*
Blue jobfish	*mrongo/kifimbo*	*Aprion virescens*
Cobia	*songoro*	*Rachycentron caudatus*
Barracuda	*hadana*	*Spyphraena spp.*
Needlefish	*mzia*	*Tylosurus spp.*
Red emperor	*vanda*	*Lutjanus sebae*
Milkfish	*mwatiko*	*Chanos chanos*
Giant manta ray	*tenga*	*Mobula diabola*
Manta ray	*kinyosi*	*Manta birostris*
Cownose ray	*kipanda*	*Rhinoptera javanica*
Shark	*papa*	*Carcharinhus spp.*
Blacktip reef shark	*papa nevingo*	*Carcharinhus elanopterus*
Hammerhead shark	*papa pingusi*	*Sphryna spp.*

Catch earnings varied between vessels and by month, with the latter part of the year providing the greatest revenue (Fig. 4 and 5). Based on data from both vessels and assuming an average of 12 fishing nights per month, the mean daily revenue derived from the sale of catches has increased over the years since the study began (Table 2). The increase exceeds the local inflation rate and though data from the year 1997 only extend to August, the complete year's revenue was likely to have been much greater since the months of September to December are typically good months (Fig. 4 and 5).

The vessels usually carry four crew members. In most months, the fishers share about 50% of the revenue, with the remainder partially reserved for operating costs such as purchase of spare parts, costs of repairs to the vessel or nets. On two occasions, whole nets were lost to large ships passing in the night. The savings by the cooperatives led to the purchase of three additional vessels between them. For 1997, each fisherman grossed about TSh60,000 (approx. $US100) per month, based on 12 nights of fishing per month.

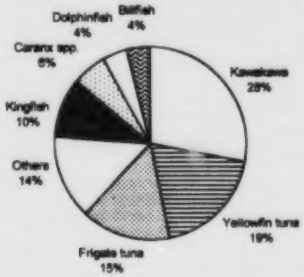

Figure 3. Mean percent composition of the catches of the fishing vessels Fikrini and Chukrani based on numbers of fish caught, May 1994-March 1995

Table 2. Mean daily gross revenue derived from sales of catches.

Year	1994 (May-Dec)	1995	1996	1997 (Jan-Aug)
TSh	17,000	28,000	38,000	33,000
$US equivalent	$37.80	$56.00	$69.10	$50.80
$US exchange rate	450	500	550	600

DISCUSSION

Both catch and revenue were between 25-30% of the values predicted by the cooperatives and included in their original proposal to the Netherlands Embassy. The number of nights fished per month averaged only 12 compared to the 19 estimated. However, after almost four years the cooperatives agree that the vessels have greatly increased their income. For the year 1997, these fishers earned about $US100/month compared to the monthly salary of schoolteachers of $US30-70. Savings have been used to pay off loans for other engines (also Ruggerini), new vessels, and instalments towards a bus for the village that significantly improved transportation to the main town of Zanzibar.

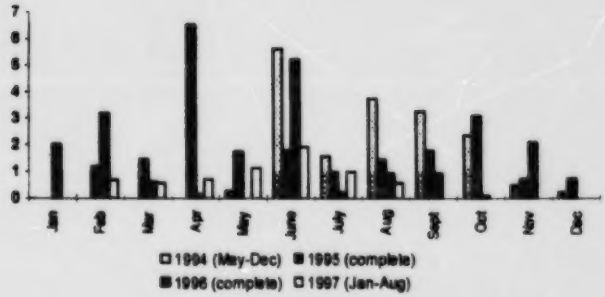

Figure 4. Mean daily catches for both vessels combined in numbers of yellowfin tuna for the four years

In November 1994, a student was welcomed aboard the vessels for 13 consecutive nights to collect additional fisheries data. The brief study provided accurate positions and duration of fishing effort as well as information on the direction in which the fish were travelling when caught and their depth in the net (Smith 1994). The potential exists to use these two dhows for further investigation of a poorly understood fishery and fishery resource. Furthermore, the interests of fishers currently exploiting these resources should be carefully considered in any future fisheries policy. The harvest from the existing stocks, about which so little is known, is directly beneficial to the local communities. The future of these activities depends on whether the Government permits large-scale commercial operations to develop. Should this happen, it is likely that the artisanal fishers would be negatively affected. A better approach would be to extend the artisanal fishery, allowing it to move further offshore with traditional gears adapted to operate in deeper water (Tarbit 1984) and to exploit the use of fish aggregating devices (FAD's) such as are now used in the Comoros and Madagascar.

The fisheries data collected through this pilot programme represent the first detailed analysis of the large-mesh artisanal pelagic fishery for Zanzibar. It is also the first time that these fishers have experienced any interest in these activities and certainly the first time that they have been involved in data collecting of any sort. This was only possible with the full cooperation of the fishers, which in turn was only achieved through the development of a sound working relationship between fishers and investigators. Their willingness was, as mentioned earlier, also facilitated through the donation of the vessels by the Netherlands Embassy.

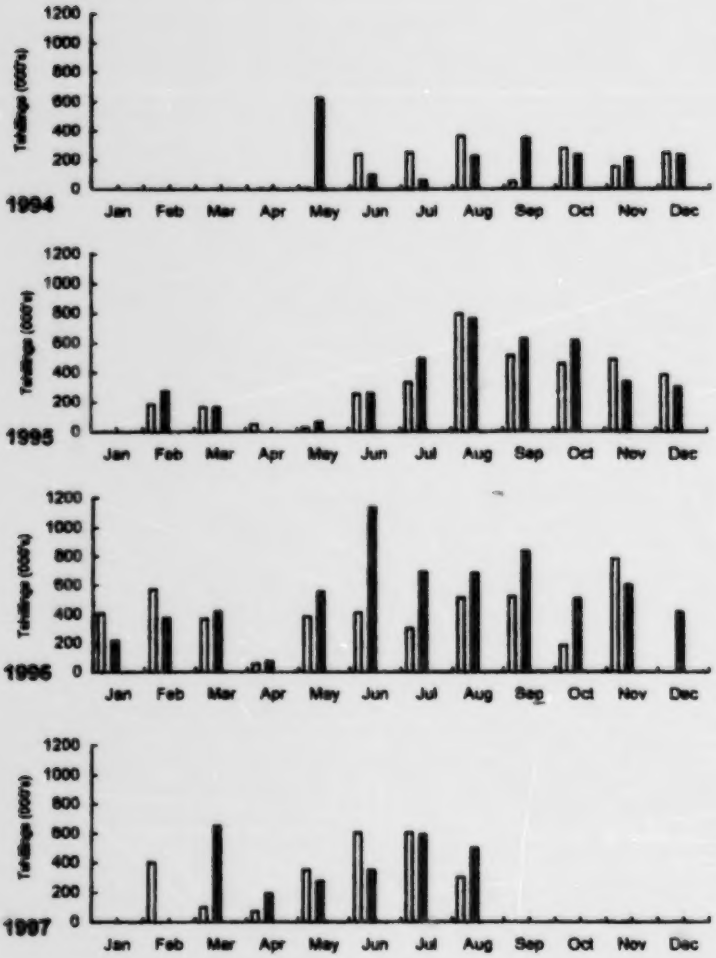

Figure 5. Mean daily catches of yellowfin tuna for both vessels over the four years. Black bars - Fikrini; white bars - Chukrani.

Despite this, close and regular supervision was essential throughout the year. Both of the shopkeepers acting as data recorders completed a brief financial and management course in town sponsored by the Netherlands Embassy. The course clearly benefited the management of their financial records.

The cooperatives would further benefit from financial advice on how to invest the profits from the fishing activities. The advice would lead to a clear statement of objectives and goals. These in turn could lead to a monitoring programme that would assist the cooperatives in achieving those goals. The present programme only followed their activities, without interfering or suggesting how and where they might dispose of their earnings. The four years' findings now provide a basis for measuring progress.

This form of assistance would undoubtedly benefit many other coastal villages situated close to deep water where large pelagic species are present. Other examples include Pemba Island, the south of Dar es Salaam, Mafia Island and along the southern shores of the mainland towards the Mozambique border. In Zanzibar, the tourism sector has developed rapidly in the last 3 years, with currently over 600 beds in the northeast coast of Unguja alone. Demand for fresh, high-quality fish from this area has increased, with fish auctions at Kigomani village now attended by representatives of nearby hotels.

Size or weight of fish and market prices were not included in the monitoring programme for the first year and it is not possible to attribute profitability to any single factor. Number of nights fished, fish size and species composition, fish prices and other factors will all play a role in determining the monthly income. The high financial returns for July-November can possibly be attributed to the higher price of fish, boosted by the main tourism season, rather than by higher catches. Further analysis of the data is required to separate these factors.

RECOMMENDATION

The data recorded under the Matemwe Fishing Cooperatives Monitoring Programme has succeeded in providing a clear insight into the artisanal pelagic fishery off northern Unguja island. The two large engine-powered dhows, purchased with the grant from the Netherlands Embassy, have been fishing effectively and landing substantial catches of tuna as well as marlin, sailfish, and several species of caranx. The annual economic benefits, though less than originally anticipated, have provided a significant boost to the economy of those engaged.

It is said that marine resource development and management schemes in developing countries have often been designed without significant consultation with, or understanding of, the users of these resources and as a consequence, they tend to fail (Johannes 1981). To avoid this, Zanzibar requires more studies that concentrate on the coastal activities referred to above, like the present report. In one year, it is possible, with minimum cost, to document a village's fishing activities and establish its impact on the economy of the village. Integrated

management of the coastal resources, that is, management of the people who use those resources, can only be achieved if the usage patterns and their impacts on the resources and economies are well known.

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Dynamics of the dema trap fishery in the coastal waters of Zanzibar, Tanzania

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INTRODUCTION

The fisheries sector of Zanzibar is divided into three main groups, the Zanzibar Fisheries Corporation (ZAFICO), the artisanal or small scale fisheries, and the fisheries co-operatives (Jiddawi 1990a). Artisanal fisheries, which involve many fishers, contributed more than 95% of the annual total catch between 1982-1989. The potential yield of these fisheries has been estimated to be about 25,000 t (Sanders 1990).

Zanzibar is a coralline island with limited arable land so most people turn to the wealth of the sea to earn their living. Commercial trawling is hindered by coral reefs which limit trawling to about 20% of the total shelf area; thus a variety of traditional fishing gear are more commonly used. The artisanal fishery operates in shallow waters in depths rarely exceeding 60 m (Ngoile 1982). Fishers use outrigger canoes (*ngalawa*), planked boats (*mashua*), dugout canoes (*mtumbwi*) and large planked canoes (*dau*) (Jiddawi 1990b). Artisanal fishing gear includes troll, fixed traps (*uzio*), small movable traps (*towe*), large movable traps (*dema*), purse and beach seines (*juya*), drift and demersal gillnets (*jarife*), scoop nets, mosquito nets, lobster and octopus spearguns and handlines (*mshipi*) (Sanders 1990).

While Fisheries policy emphasizes the use of modern fisheries techniques, socio-economic constraints limit use of these methods. The 1982-1989 fisheries censuses reported that gillnets were the most common fishing gear in Zanzibar. However, further expansion of the gillnet fishery is probably limited by the inability of fishers to obtain imported nets and twine and the low availability of locally made gillnets. Similarly, the lack of hooks and nylon twine for handlining has forced many fishers to return to the use of traps. The censuses reported that *dema* traps were the second most common fishing gear used in Unguja Island and were used by 19.3% of the fishers on the island to harvest reef finfishes and crustaceans. Traps are impounding devices into which fish are lured and captured (Recksiek *et al.* 1991, Whitelaw *et al.* 1991).

Trap fishery studies are useful for studying complex multispecies communities as they can be set selectively for certain fish species. They have proven especially effective when used in conjunction with visual census methodologies for rapid stock assessment of coastal waters in developing tropical countries (Ferry and Kohler 1987).

Despite the importance of traps to the fishers and their potential for increasing production, *dema* traps have never been the subject of intensive investigation and there are few reports about the trap fishery of Zanzibar. To help in filling this knowledge gap, we conducted the present study of trap catches to:

- identify the principal fish species caught by *dema* traps;
- determine the effect of habitat and season on *dema* traps catches;
- examine the fishery potential and estimate the annual yield of *dema* traps.

MATERIALS AND METHODS

The study was conducted at 2 different sites, Ras Nungwi, on the northern tip of Unguja Island and Bawi Island off Zanzibar town, on the western side of Unguja Island (Map 1). Each site comprised 3 stations, which were chosen on the basis of substrate and depth. Station 1 had a coralline substrate. Station 2 had a sand substrate and Station 3 was a seagrass bed. Thirty-six traps were deployed, 6 at each station. Each trap was 1.8 m long by 1.2 m wide and 0.7 m deep. The traps were baited with sea weed, sea urchin, bivalve, squid, sardine and fish offal. The traps were set approximately 6 m apart to increase the probability that fish entering the traps came from the same population (Ferry and Kohler 1987). Traps were hauled after 2-3 days and catch results recorded that day. Fish samples were kept separately in plastic bags corresponding to site and habitat until examination. Catches were identified and sorted to species using identification guides of Bianchi and Fischer (1984), Bianchi (1985), and Smith and Heemstra (1991). Each species group was weighed separately. Sampling was done twice a month using a motorised boat.

Data analysis

Species composition among habitats and season were compared by the faunal similarity index of Moles (Ferry and Kohler 1987). Moles index varies from 0.0, when no species are shared, to 1.0 when two populations are identical in the proportional distribution among species. Seasonal variation in species composition was examined by comparing species of the initial month (May) with species of each succeeding month.

Since the catch rate data were not normally distributed and variances were heterogeneous, variations in catch rates among substrates were analysed using Kruskal-Wallis test, a non-parametric equivalent of 1-way ANOVA (Zar 1984). This was followed by Tukey's test for multiple sample comparison. Differences at $p<0.05$ were considered significant. Catch per unit effort (CPUE) was recorded as kg/trap-day.

The Shannon-Weaver diversity index (Zar 1984) was used to calculate species abundance relative to substrate and season. This index combines number of

species and their relative abundances. Differences in species diversity indices between substrates were analysed by Student's t-test (Zar 1984).

RESULTS

A total of 26 families, 44 genera and 92 species were identified from 34 days of sampling (Table 1). The total catch was composed of 1,401 fish and weighed 186.8 kg. Catch per unit effort was 3.4 fish/trap-day. Goatfish (Mullidae) was the most common family and constituted 20.5% of the total catch by number. *Parupeneus barberinus* was the dominant species, constituting 14.1% of the total catch by number of fish and 68.9% of all goatfish.

The second most common family was snapper (Lutjanidae), which represented 15.2% of the total catch. *Lutjanus johnii* was the dominant species of snapper and constituted 10.1 % of the total catch and 66.2% of all snappers. Mean daily catch was 0.195 kg/trap. Mean daily effort was 31.4 traps and mean daily total catch was 6.1 kg/trap-day (Table 2). Highest catch was in November and April while the lowest catch was in October (Table 2).

Fish abundance (catch rate) in coralline substrate (number of fish=410) and seagrass beds (number of fish=435) was significantly higher than over sand substrate ($p<0.001$) (number of fish=290). Tukey's test revealed that variation existed between sand/seagrass ($0.05<p<0.025$) and sand/coralline ($0.05<p<0.025$) but no difference in fish abundance was observed between the coralline/sea grass substrates ($p>0.1$).

Species composition also differed between habitats. The fauna similarity indices of Moles were 0.3 (coralline/sand), 0.7 (coralline/seagrass) and 0.4 (sand/seagrass). Seasonal variation in species composition was observed within habitats (Fig. 1). Diversity differed significantly between sand/coralline ($0.02<p<0.01$) and sand/seagrass ($p<0.001$) (Fig. 2). There was no difference in diversity between coralline and sea grass ($0.2>p>0.1$). Seasonal variation in species diversity occurred within a habitat. Variation occurred within coralline ($p<0.001$) and sand substrate ($p<0.001$) while no variation in diversity occurred within seagrass bed ($p>0.5$) (Fig. 2).

Table 1. Fish families, genera, number of species caught by *dema* traps May 1994 - June 1995 in Unguja (Zanzibar) waters

Family	Genus	No. of species	No. of individuals
Acanthuridaec	*Acanthurus*	2	90
Balistidae	*Rhinecanthus*	1	19
Chaetodontidae	*Chaetodon*	3	79
	Heniochus	1	2
Channidae	*Chanos*	1	2
Diodontidae	*Diodon*	1	1
Haemulidae	*Plectorhinchus*	4	15
Holocentridae	*Sargocentron*	1	2
Labridae	*Coris*	2	13
	Cheilinus	2	24
	Cheilio	1	1
	Hemigymnus	2	5
Lethrinidae	*Lethrinus*	8	152
	Monotaxis	1	10
	Gymnocranius	1	2
Lutjanidae	*Lethrinus*	9	213
Monacanthidae	*Alutera*	1	8
	Stephanolepis	1	4
	Cantherhines	2	12
Mullidae	*Parupeneus*	4	279
	Upeneus	3	8
Muraenidae	*Echidna*	2	22
	Gymnothorax	1	13
Nemipteridae	*Scolopsis*	3	10
	Nemipterus	1	7
Ostraciidae	*Ostracion*	2	28
Pomacanthidae	*Pomacanthus*	1	10
Pomacentridae	*Abudefduf*	3	30
	Dascyllus	1	7
Scaridae	*Calotomus*	1	34
	Leptoscarus	1	22
	Cetoscarus	1	6
	Scarus	4	57
Scorpaenidae	*Pterois*	1	2
Serranidae	*Epinephelus*	5	34
	Cephalopholis	1	1
Siganidae	*Siganus*	4	103
Sillaginidae	*Sillago*	1	1
Sparidae	*Acanthopagrus*	2	4
Synanceiidae	*Synanceia*	1	32
Tetraodontidae	*arothron*	2	25
	chelonodon	1	9
	lophodiodon	1	1
Zanclidae	*Zanclus*	1	2
Total		92	1,401

Table 2. Monthly catch and effort for trap fishing in Zanzibar (S.D. = standard deviation)

Time (months)	Mean daily catch (kg)	Daily effort (no. of traps)	Mean daily C/f (kg/trap) ± S.D
May 1994	6.13	34	0.180 ± 0.03
June 1994	6.71	30	0.224 ± 0.06
July 1994	8.02	33	0.234 ± 0.04
August 1994	4.28	31	0.138 ± 0.06
September 1994	3.96	27	0.136 ± 0.06
October 1994	2.56	34	0.076 ± 0.03
November 1994	10.55	31	0.340 ± 0.08
December 1994	5.39	35	0.154 ± 0.04
January 1995	4.78	30	0.159 ± 0.01
February 1995	5.16	28	0.184 ± 0.10
March 1995	4.51	35	0.129 ± 0.04
April 1995	11.02	29	0.379 ± 0.01
Mean ± S.D.	6.094 ± 2.59	31.42 ± 2.75	0.195 ± 0.09

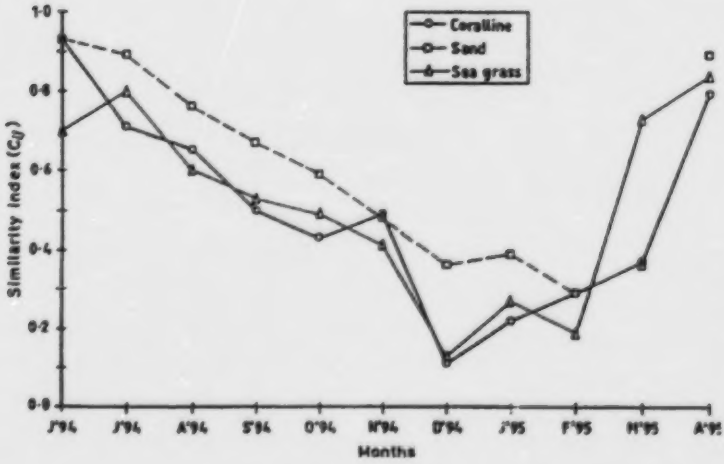

Figure 1. Seasonal values of similarity index of Moles (C_{ij}) computed among initial collections (May) and the collections of each succeeding month of the sampling period May 1994-April 1995.

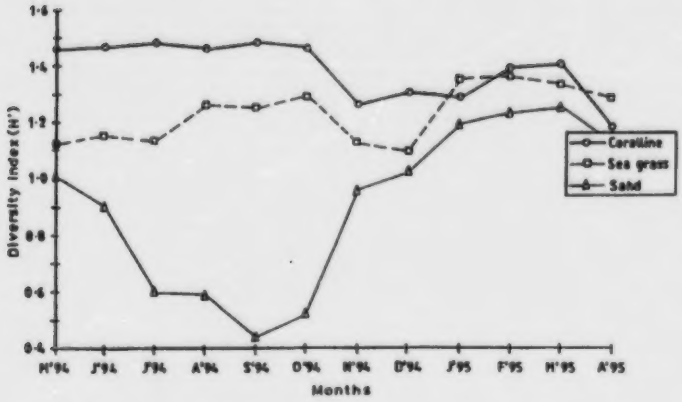

Figure 2. Seasonal variation of Shannon-Weaver species diversity index from coralline and seagrass beds, and sand substrates.

DISCUSSION

Catch rate data exhibited a non-normal distribution due to some poor or zero catches which might have been caused by predation whereby once a predator enters a trap it kills or chases away prey (Makame Usi, personal communication). Poor catches could also be related to weather conditions. For example, we observed that when the sea was rough the catch was poor. It is possible that fish take refuge under reef crevices, boulders or in sea grass during rough sea conditions. Poor catches could also be caused by lengthy soak times. According to Munro (1974), an increase in soak time can be associated with a decrease in catch. This was attributed to a high escape rate. Munro (1974) observed that the longer the fish remained in the trap the more familiar they became with the surroundings and thus were able to locate the entrance and escape. Soak time in this study was 2-3 days. The soak times in Koslow *et al.* (1988) were 1-5 days and 1-6 days in Ferry and Kohler (1987).

The mean daily catch rate (0.195 kg trap/day) reported in this study conforms with studies conducted elsewhere. For example, Campos *et al.* (1994) reported catch rates of 0.14 kg/trap-day. Acosta and Recksiek (1989) reported catch rates ranging from 0.03-0.07 kg/trap-day. Gulland (1983) suggested that the average catch per unit trap can be used as an index of stock abundance.

The increase in fish catch between November and April coincided with the northern monsoon during which the shallow thermocline develops (Bryceson

1977). Fish move nearer to the surface and are concentrated in the narrow layer above the thermocline.

Fish abundance and species diversity

Difference in fish abundance among habitats can be explained by differences in spatial heterogeneity which in turn are caused by biotic and abiotic factors. Brackel (1981) reported that while coral reefs and seagrass communities are biologically interconnected, they differ in abundance of individual organisms. In this study it was observed that fish abundance did not differ between the two ecosystems ($p>0.05$). Coral reefs are the most extensive and shallowest marine community (Gaudian 1991) while primary production is maximum from sea grass beds (Zieman 1975).

The complexity in microhabitat and the high productivity may support an abundant and varied fish fauna which can share the resources in space and time (Ogden and Lobel 1976). The substrate complexity and high productivity of both habitats may lead them to exhibit similar abundance and diversity, as observed in this study.

Sand habitat is covered by sparsely distributed marine plants, decomposing marine organisms and detrital organic matter (Brackel 1981). Sand substrate can support macrobenthic invertebrates which provide food for fish from adjacent coral reefs and sea grass beds. Fish abundance and diversity measures were low owing to a lack of diversity in microhabitat.

Species composition

The results suggest that there is overlap in species composition between coralline/seagrass habitats. Heck (1977) and Olsen *et al.* (1973) reported overlap of species from the two ecosystems during the course of their studies. Overlapping could be caused by spatial and temporal sharing of the habitats. Some species, which spend their adult lives in reef communities, live as juveniles in adjacent sea grass beds (Ogden and Zieman 1977). Various species which spend the day in reef communities move into seagrass beds to feed at night (Randall 1965). Many species which occupy reef habitats during low tides move into seagrass beds to feed during high tides (Fishelson 1980).

RECOMMENDATION

Trawl activity is restricted on the East African coast owing to the narrow continental shelf, coral reefs, and strong currents of the East African Coastal Current (Tarbit 1976). Thus, the offshore areas which comprise about 70% of the

total continental shelf area remain relatively inaccessible. This implies that inshore fisheries will probably remain the most important component of fisheries sector in Zanzibar. Clearly, the well-being of Zanzibar is linked to the artisanal fishery sector and the need to maintain and enhance this sector cannot be overemphasized.

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Section IV: Biodiversity and Eco-tourism

The inshore demersal fish species of the eastern part of Lake Tanganyika and their need for conservation *Simon G. M. Ndaro*

INTRODUCTION

Lake Tanganyika is one of the most fascinating ecosystems on our planet. Its size (33,000 km^2), depth (maximum depth 1,470 m), grandeur, geological history (20 million years) and, above all, its rich and beautiful endemic fish fauna, combine to make the lake's aesthetic and scientific attraction comparable to few other ecosystems (Coulter 1991).

The lake is known to contain over 500 animal species. About 214 species of fish (85% endemic) have been identified and probably more await discovery. Among the demersal species, over 134 species are Cichlidae, of which 130 species are endemic. Some catches are composed entirely of cichlids. Furthermore, among the Great Lakes of Africa, Lake Tanganyika has the largest number of non-cichlids fishes including 20 families, 57% of which are endemic. Many of these are otherwise only known from riverine systems. The lake is also remarkable for the extensive speciation among other phyla. Most of the invertebrate phyla are represented by several endemic species. Some are thought to be of marine origin, as for example the medusoid coelenterates (*Limnocnida tangayikae*) and potomonid crabs (Beadle 1981). The great age of the lake and the long period of isolation are presumed to account, in part, for the tremendous speciation. Nevertheless, while much is known about the lake's fauna, details of its origin are still the subject of controversy. For example, the significant speciation of the non-cichlids is not seen in the other great lakes in Africa, and remains unexplained as does the co-occurrence of both substratum spawning and mouth-brooding cichlids in the same lake. How these two groups have partitioned the resources of the lake remains a mystery. These features combine to make Lake Tanganyika a natural laboratory for fish research by taxonomists, systematists, ecologists, ethologists, and geneticists.

Perhaps even more important than its scientific value is the importance of the lake's fisheries to the people of the region as a source of inexpensive animal protein as well as employment. Previous stock assessments for the lake have estimated a biomass of 2,800,000 t (Johannesson 1974) but this estimate was based mainly on the more abundant pelagic stocks.

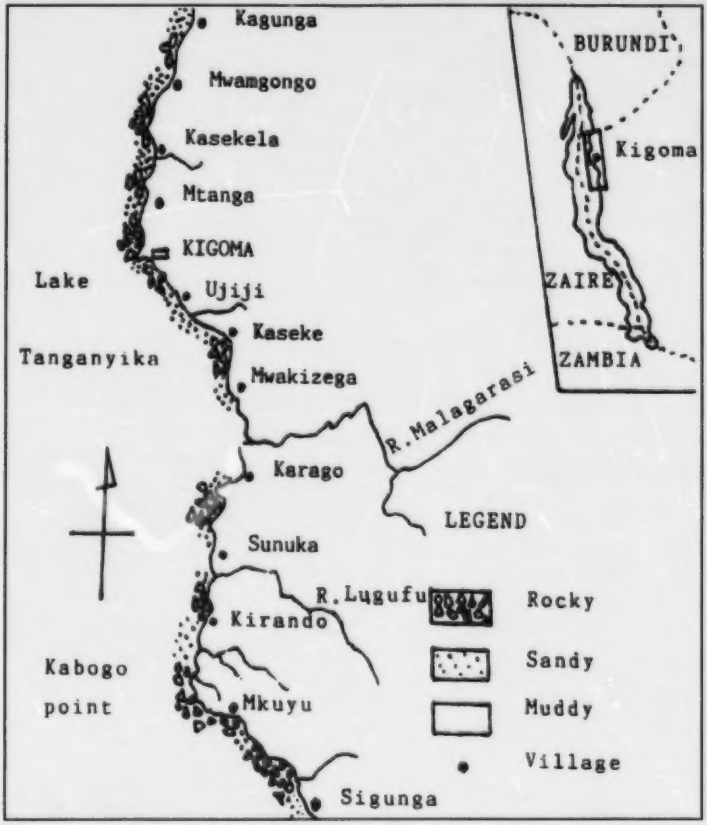

Figure 1. Map of the area investigated, showing the habitat substrate and villages near areas of sampling

The demersal inshore stocks have so far attracted little research attention even though these stocks contribute substantially to the annual fish catches. Owing to their ease of capture with simple methods, they are important in the traditional fish markets and are fished by many people living close to the shore.

The intent of this paper is to examine the means to achieve sustainable harvest practices for the people who rely on the lake for survival while emphasizing the need to preserve the integrity of the lake's fauna for the wealth of scientific information it offers. The discussion and recommendations are based partly on observations recorded by the author in 1988 and1989.

The demersal fish habitat

The demersal species inhabit the shallow waters that are confined to a narrow strip along the shoreline. Of the lake's 1,500 km of shoreline, 450 lie in Tanzania on Lake Tanganyika's eastern shore. Along most of this coastline, the depth increases to more than 100 m almost immediately except in a few places near river mouths and in some shallow bays where the 100 m depth contour can be up to 1 km from shore. Since waters deeper than 200 m are anoxic (Beadle 1981), most demersal species are limited in distribution to this narrow inshore region of the lake. This same region provides the feeding grounds for these fishes as well as the substratum on which many lay their lay eggs and rear their young. Thus, this shallow inshore strip forms the basis of the demersal fish productivity. The limited extent of the habitat, in spite of the overall size of the lake, implies obvious limits to productivity as well as emphasizing the need for careful management and the use of non-destructive and selective harvesting methods.

Beach seining

One of the activities in Lake Tanganyika that is most destructive to the habitat is beach seining. The local people use beach seining to catch sardines (*Stolothrissa tangayikae* and *Limnothrissa miodon*) as well as many inshore fishes. Although the sardines do not permanently live inshore, the traditional technique of catching them involves light attraction during moonless nights and luring them towards the nearshore habitat. Fishing starts in waters approximately 5 km offshore; then the light is slowly moved towards the shore while paddling slowly to avoid disturbing the fish. When the boat reaches the shore, the attracted fish are surrounded by a seine and towed ashore.

Directed fishing for the inshore cichlids is mainly done by beach seines in shallow inshore areas over smooth (sand-mud) bottom within bays and on open sandy shore stretches (Fig. 1). Gillnets, weirs and handlines are also used to a slight extent to catch demersal fishes.

At Sunuka in July 1989, on the eastern shore of Lake Tanganyika south of Kigoma Town, there were 20 beach seines and up to 35 canoes operating on a nightly basis. As each canoe returned, a beach seine surrounded it. Thus, during each night the lake bottom was fished at least 35 times. Similar activities could be observed near the fishing villages of Kagunga, Mtanga, Kaseke and Mwakizega. Juvenile cichlids dominated catches in these villages. They contributed 59.9% by number and 27.7% by weight of the total catch in a survey conducted from Kagunga, a Tanzanian northern border town, to Sigunga, a fishing village about 70 km south of Kigoma town (Ndaro, unpublished data) (Table 1). Catch rates were generally low in these areas, usually amounting to less than 10 kg per haul. On average, cichlids accounted for over 90% of the catch by number and 79% by weight (Table 2). In many areas, the distribution of

fish was very sparse and highly dependant on habitat. For instance, catches in confined bays tended to be higher than those along open sandy shores (Table 1).

Table 1. Catch per haul at different stations on the eastern shores of Lake Tanganyika during a research survey conducted south of Kigoma from April 4, 1988 - May 8, 1988.

Station	Habitat Type	Haul Number	Kg	Kg/haul
Sigunga	sandy, open	1	1.8	
	sandy, confined	2	14.8	
	sandy, confined	3	16.4	
	open, pebble	4	5.0	
	sandy/pebble	5	3.7	
	sandy, rocky	6	14.1	
	muddy, confined	7	5.0	
	average	1-7		8.8
Kirando	sandy, confined	8	46.7	
	sandy, confined	9	11.2	
	sandy/pebble	10	18.0	
	average	8-10		25.3
Sunuka	sandy, open	11	4.1	
	sandy/muddy	12	2.0	
	average	11-12		3.0
Karago	muddy, confined	13	11.2	11.2
Kaseke	rocky, confined	14	7.1	
	sandy, open	15	2.5	
	average	14-15		4.8
Kigoma	sandy, open	16	4.7	4.7

Beach seining is thought to be destructive for a variety of reasons. The bottom line of rope and sinkers drags on the lake bottom and tends to displace or crush sessile organisms. The benthic infauna and epifauna may also be damaged from constantly changing sedimentology (Paine 1966). This must affect the demersal fish prey distribution and abundance, especially for the bottom deposit feeders.

Seining also leads to significant juvenile fish mortality, egg and nest destruction, and the capture of gravid, spawning or brooding females. Furthermore, fishing activity may drive fish away from the grounds because the grounds are no longer suitable for breeding and survival of the young. These effects are detrimental to the inshore stocks and may be contributing to stock declines. The variation in fish abundance in this region (Table 1) may be related not only to the occurrence of varied biotopes in the lake but also to the intensity of beach seining, especially in areas of open sandy shores.

Data on the seine catches of demersal fish are not available but since it is a year-round fishery it can be assumed that the catches are significant. The lack of fish in the inshore region, during the fish stock surveys conducted in 1987-1989, is probably indicative of the negative effect of beach seining. Of the six stations, four had catch rates lower than 10 kg/haul (Table 1). Of 16 seine hauls, only seven (six of which were confined to two very close areas, Kirando and Sigunga) yielded catches above 10kg/haul. Low catch rates (<5 kg/haul) were observed near Sunuka, Kaseke, and Kigoma where there are significant seining activities.

Table 2. The percentage by number and weight represented by all cichlids or juvenile cichlids in all fishes caught in Lake Tanganyika between Kagunga and Sigunga during fish stock surveys from May 3, 1989-May 13, 1989.

Station	Percent composition			
	All cichlids		Juvenile cichlids	
	no.	wt.	no.	wt.
Kagunga	84.3	96.0	76.2	37.4
Kigoma	95.0	92.9	65.4	26.0
Kaseke	97.4	96.3	60.4	29.9
Mwakizega	97.7	72.2	53.5	19.4
Karago	77.3	24.8	22.0	2.5
Sunuka	97.2	90.3	56.0	31.8
Kirando	96.0	87.6	64.9	18.3
Sigunga	95.0	72.4	80.4	33.6
Average	92.5	79.1	59.9	27.7

Because of the peculiar morphometry and topography of Lake Tanganyika (Fig. 1), some of the habitats are not fished by beach seines. These include rocky habitats, confined muddy bays and submerged rocky promontories. Stock surveys indicate higher catch rates in some ecological zones (Table 2). Kirando, a confined bay, exhibited catch rates of up to 46 kg/haul. These special ecological zones may act as core spawning areas that produce most of the recruitment. It is not known how many of these species, particularly cichlids, tend to be restricted to specific habitats. Thus in the event of overfishing, specific habitats may be slow to rebuild. For example, depletion of stocks in sandy bottom areas cannot expect immigration from species in adjoining rocky areas (Coulter 1991). This means that beach seining may slowly destroy the inshore fishery. In fact, I have observed that fish now appear to be absent from certain areas on the eastern shore.

Live fish trade

In addition to the food fishery there is a lucrative live fish trade on Lake Tanganyika. Cichlid species are the most popular. Most inhabit special biotopes

of the lake such as near rocky promontories, in deep rocky habitats, and over sandy bottom in confined bays. Over 30 species from the lake's eastern shore are used in this trade (pers. comm.). They include *Juridochromis* spp., *Cyphotilapia frontasa, Lamprologus* spp., *Ophalmochromis ventralis, Haplochromis horei, Cyathopharynx furcifer, Tropheus* spp., *Lamprichthys tanganicus, Cardiopharynx* spp., *Haplochromis* spp. and *Lamphochromis* spp. Live fish collection does not necessarily destroy the environment but does reduce abundance, especially since many of these species are naturally rare in the lake.

There is one live fish exporting company (Kigoma Aqua Products Ltd.) on the eastern shore of Lake Tanganyika, based in Kigoma, Tanzania. This company exports to North America and Europe but does not release statistics on the numbers or weights traded. However, given the fame of this company (Kigoma Aqua Products Ltd. was the 1992 Paris First Prize Winner for continued flow of good business between North and South, Daily News, April, 1992), the trade volume is likely high. The live fish trade might be responsible for the decrease (disappearance?) of some fish species from the lake. To date, no conservation measures have been undertaken by the Government of Tanzania to protect any of the exported species. Since the value of these species is directly related to their rarity and because many species are restricted to special biotopes, it can be assumed that un-controlled capture will inevitably lead to extinction for some or many of these species.

The importance of the demersal fishes

Previous studies on Lake Tanganyika have concentrated on acoustic stock assessment and biology of pelagic sardines and *Lates* spp. (Chapman 1976). These studies did not incorporate the acoustic target strengths of cichlids and would have also underestimated the near-bottom presence of fish (Bayona 1988). Therefore, while the study indicated a biomass of 2,800,000 t and annual yields of 300,000 t, the potential harvest that could be contributed by the demersal stocks (cichlids mainly) remains unknown. Estimates for the Tanzanian part of the lake indicate an annual yield of approximately 100,000 t (Bayona *et al.* 1989). Currently about 40,000 t are caught annually, all species combined (Bayona 1988).

Catch statistics from the Tanzanian part of the lake do not show the proportion contributed by the demersal fishes. However, I have observed that substantial quantities of cichlid and non-cichlid fishes appear in markets in Ujiji, Kigoma and surrounding villages throughout the year. Thus the inshore demersal fish stocks must contribute greatly to the animal protein requirement of the people in the region. Since the fishing grounds are close to shore and because this fishery can be exploited with simple and inexpensive gear, the inshore fishery makes an important contribution to local people's income and nutrition. Along some parts

of the shoreline, owing to the lack of arable land, inshore fishing is the only occupation and is therefore essential to survival.

The live fish export trade must also flourish and it also depends primarily on the inshore stocks. This trade provides valuable foreign exchange and employment. Finally, the remarkable diversity in the lake provides a natural laboratory that must be protected for scientific study. The importance of the resource is obvious, what is required is a basis for sound management. Recently, there has been much regional and international concern expressed about the conservation of the Lake Tanganyika ecosystem. For example, the symposium on Resources Use and Conservation of the Great African Lakes, held in Bujumbura, Burundi, December 1989, emphasised the need to conserve the Resources of Lake Tanganyika. The workshop on Lake Tanganyika Conservation and Biodiversity, Bujumbura, Burundi March, 1991 recommended that national authorities act to conserve the lake and its fauna. The International Water Tribunal (IWT), in its 1992 meeting held in Amsterdam, showed much concern over the fate of Lake Tanganyika's ecosystem integrity. Unfortunately, while much concern is being expressed, human activities on the lake continue to threaten the very existence of the lake fauna and the most vulnerable group at the moment is the inshore demersal fish species.

RECOMMENDATIONS

Traditional fishing uses use small mesh size seines to catch sardines but these have harmful affects on the lake bottom and catch many juveniles of the demersal species. In their place, we should encourage the use of other traditional, but more selective, methods such as gillnets, handline, stake traps and long line for catching the inshore demersal species. Mesh size can be controlled in the gillnet fishery. Since these methods are operated offshore they cannot harm juvenile fishes of the inshore region. These methods are sufficiently effective for the sardine fishery and can be afforded by many in the fishing villages.

There is a need to prevent destructive fishing methods, such as icthyotoxins, from being used in the rivers and streams that flow into the lake. Some of the inshore species travel upstream for spawning and therefore rivers and streams act as stock reserves that replenishes the inshore stocks. This is especially true of the riverine non-cichlid species.

Exporting companies should be forced to declare the volume of trade by species as a condition of license. Currently, the details of this trade are kept confidential even though it is possible that some species have become extinct or are nearing extinction through this unmonitored and secretive business. The exporting

company should also be made to re-invest earnings in rehabilitation, or conservation programs including fish hatcheries for purposes of re-stocking and stock enhancement.

Effective management of these resources requires adequate research into the ecology, biology and assessment of the stocks, including those important to the live fish trade. Perhaps the unique features of the lake, in addition to the pressing socio-economic issues will serve to attract the interest of naturalists, conservationists and other interested scientists to do appropriate research in this area. So far there has only been general statements on the abundance of inshore demersal stocks, but, as indicated in the present report, there is much to learn.

It has been suggested that overfishing results solely from using inappropriate gear rather than limitations to demersal fish abundance and productivity (Bayona 1991, Ndaro 1992). Beach seining cannot be applied in rocky areas or in areas of abundant submerged and emergent vegetation but many fish may inhabit such areas. We therefore require a system of resource inventories. The Lake Tanganyika ecosystem comprises a mosaic of repetitive ecological habitats that harbour different fish populations, the distribution of which is governed by several factors such as depth, substratum type, food, and dissolved oxygen.

Finally, local people must receive extension services to make them aware of the need to conserve the inshore fish fauna. A second phase will be to involve them in the conservation process.

In summary, this review of the Lake Tanganyika demersal fisheries recommends:

- banning the use of beach seines;
- banning the use of fish toxins in inflow streams and rivers;
- encouraging the use of scoopnets, liftnets and purse seines or ring nets in the sardine fishery;
- monitoring the live fish trade;
- enhancement of fish stocks;
- more directed research on these important fisheries;
- increased public education

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Dolphin tourism in Kizimkazi, Zanzibar: What is it? Who profits? What has it meant for the village?

Angelique Todesco

INTRODUCTION

The first phase of the Unguja Dolphin Project was established in Kizimkazi, Zanzibar, May 1997. The project has two permanent staff based in Kizimkazi whose main duty is to organize groups of volunteers to collect observations. Groups of up to 12 "eco-tourism" volunteers from Europe stay in Zanzibar for two weeks. The focus during the two weeks is the observation and identification of individual dolphins as well as monitoring tourists who are visiting the dolphins. The project has also collected observations on the effects of dolphin tourism on the villagers.

Dolphin tourism has become one of the most important sources of income for Kizimkazi but the long-term viability of this activity requires proper guidelines and procedures. By observing the dolphins and their visitors, we hope to provide the background information for development of these guidelines. The specific aims of the project included:

- establishing a permanent information and visitors centre;
- training guides who will be able to inform tourists and accompany boats;
- establishing a licensing system for participating vessels;
- training all pilots in correct boat management around dolphins;
- limiting the number of trips/day such that no more than three are active at any time;
- promoting better safety practices including the establishment of a first aid station at the information centre, and staffing the centre with a person trained in first aid.

Cetaceans in Zanzibar

There have not yet been any detailed studies of the marine mammal population in Zanzibar waters; however, this project has confirmed the presence of bottlenose, Indo-Pacific humpback and spinner dolphins as well as humpback whales. Carwardine (1995) states that there are possibly 13 species of whales and eight species of dolphin in or near Zanzibar waters.

It is generally believed that cetaceans evolved from land mammals (Fig. 1). In evolutionary terms, they are a relatively new group having only been present in their current form for about 15 million years.

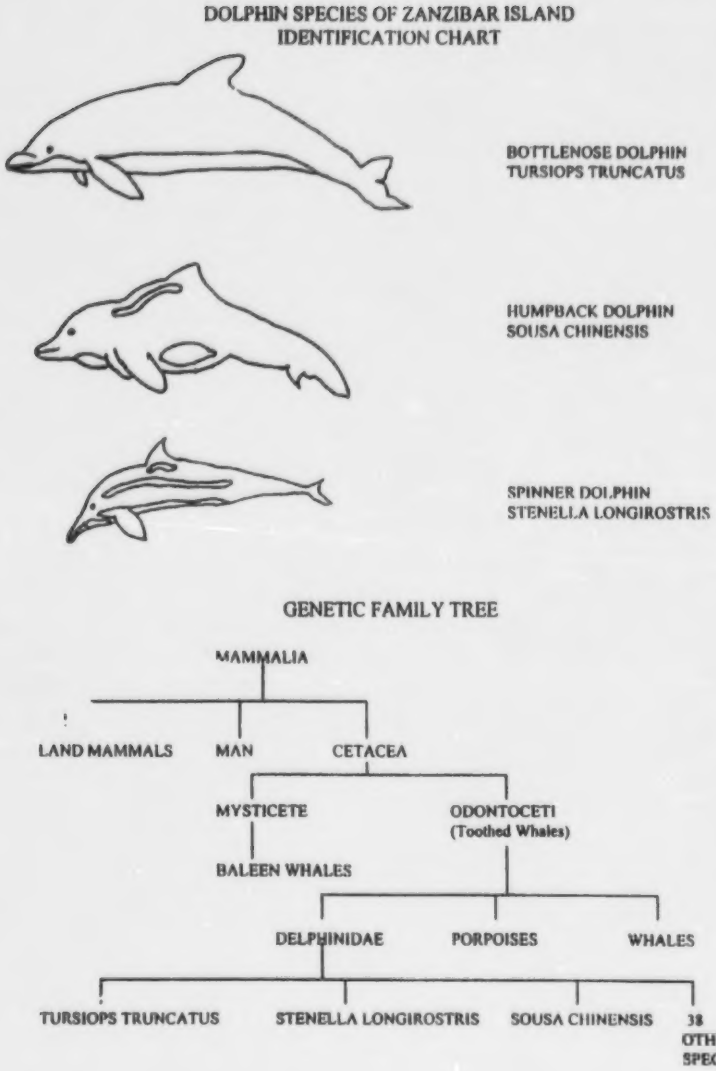

Figure 1. Dolphin species of Zanzibar

However, while relatively new arrivals (some fish groups have been present for about 350 million years) they are well adapted to their environment. They are possibly more hydrodynamically shaped than fish and while they usually travel at 5-11 km/h, they can reach speeds up to 29-35 km/h.

Dolphins can be found in all habitats except the polar regions. They are social and usually travel in groups. These vary in size from small family groups to large herds numbering in the hundreds. The coastal varieties, such as are observed near Zanzibar, usually stay in smaller groups. Coastal varieties also tend also to be smaller in body size.

Three species are commonly seen near Zanzibar (Fig. 1). The bottlenose dolphin (*Tursiops truncatus*) has a short distinctive beak or rostrum, and a tall, centrally placed dorsal fin. The dorsal colouring is dark grey to brown with lighter flanks and an even paler belly. This colour pattern is typical of most dolphins and fish and acts as natural camouflage. The average length of a bottlenose is 3-4 m. Males tend to be larger than females. An adult bottlenose weighs 250-500 kg. Older animals have spots on their flanks and belly. This species is known for its curiosity and has many recorded interactions with man. Pod size averages 20-25 animals.

The Indo-Pacific humpback dolphin (*Sousa chinensis*) has a stocky body and a prominent hump of fatty tissue at the front of the dorsal fin. They have a long slim tapering beak. Their colour varies from white in the seas off China to a silvery grey in animals near Zanzibar. They display a distinctive way of swimming. When surfacing to breathe, first the head emerges, followed by the hump. As the head submerges, the body arches and dives with the tail in the air. The Indo-Pacific dolphin is very shy. It is rarely observed in comparison with the bottlenose dolphin. Pod size averages about six.

The spinner dolphin (*Stenella longirostris*) inhabits deeper waters offshore. Fishers far off the coast at Kizimkazi occasionally sight it. Spinner dolphins are often seen in the north of Zanzibar near Nungwi (Ortland 1997). The group or pod size tends to be much larger than the bottlenose dolphin. This is the smallest of the three species we typically observe in Zanzibar. It only reaches 1.8-2.0 m in length and averages 45-75 kg in weight. The body is slim like the bottlenose dolphin. The beak is very long and slim from which the specific name is derived. It has long pectoral fins and a dark dorsal area. This dolphin is noted for its high spinning jumps. Up to seven spins have been recorded in one jump.

Dolphins in Kizimkazi

The dolphins have been observed near Kizimkazi since at least 1991. Previously, fishers captured dolphins for shark bait, but about six years ago, they began to

recognize that the potential value from tourism far exceeded that of shark bait. Our observations of several individually marked dolphins, using natural markings in the dorsal fins, indicate that the pod is at least seasonally resident in the area.

We assume that the area's attraction for dolphins is based on food resources. The fishers claim that fish and invertebrates are abundant in the area. In particular, there is a large amount of squid, a favourite of dolphins. The area frequented most by the dolphins is relatively small. About 70% of our sightings have been reported from within a 2-km^2 area. The estimated size of the local bottlenose dolphin population is 50-70, although they usually travel in smaller family groups of four to 25 (Table 1). We have identified 38 individual bottlenose dolphins but not all of these are seen regularly. We have confirmed observations of five baby bottlenose on a single day.

Table 1. Per cent of days which included observation of dolphins by species (1997)

Dolphin species	May 18-July 17	July 18 - September 23
Bottlenose	23%	22%
Humpback	4%	1%
Bottlenose and humpback	52%	59%
No dolphins	21%	16%

It is difficult to estimate the numbers of humpback dolphins, as they are much more elusive and therefore harder to identify to individual. The largest number seen since our investigation began is about 15 and that was on one occasion. We believe that the local population is about 20. We have identified only six individual humpback dolphins. The maximum number of baby humpback dolphins seen at one time is two. When we collect data, we also record external factors such as weather, sea conditions, tides, and phases of the moon. There does not seem to be a special time of day when they are best observed. The chance of seeing a dolphin in a day is about 80%.

The Kizimkazi Economy

Kizimkazi is composed of two villages, Mkunguni and Dimbani, with different chiefs. The combined population is about 3,000. Before dolphin tourism, the main source of income was fishing. This income was supplemented by the production and sale of charcoal, building lime, and to a lesser extent, boat building. Each year fishers from northern areas of the island arrive to fish from November-February. These fishers pay TSh6,000 for this privilege. The women contribute to the household economy by cutting firewood that they sell to middlemen for sale in Zanzibar Town. They also make rope from coconut husks

as well as mosque hats (*kofia msikitini*) for sale in Zanzibar. There is little agricultural activity. Most of what is produced is used for home consumption. There are a few papaya trees but they receive little care. Baobab fruit are sometimes sold.

Several fishing methods are used in Kizimkazi. These include handlines, nets, basket traps (*dema*), spearfishing and fence traps (*uzio*). The choice of method is dependant on the season as well as the phase of the moon. Fence traps, for example, are used November-March. Invertebrates are collected while skin diving with spears. Sharks are captured using anchor nets or lines attached to fixed buoys. Operation of these techniques causes little harm to the environment. There is an ecological officer in the area to oversee the activities of the fishers. The smaller fish are kept for personal consumption while the larger specimens are sold either to local fishmongers or taken to Zanzibar markets.

The economics of dolphin tourism

When dolphin tourism started in Kizimkazi, there were no motor boats. Tourists were transported in the local dugouts (*ngalawas*). Although more profitable, since no petrol was needed, the trip was long for the tourists and arduous for the operators. The vessels were also small and only carried two or three passengers. These disadvantages let to the introduction of the motor boat. However, the purchase cost of a motor boat prohibited participation by local fishers, as only wealthy individuals can afford the purchase and operating costs.

Table 2. Boat and purchase costs

	New		Used	
	TSh ('000)	$US	TSh ('000)	$US
Boat	1,500-2,000	2,000-3,000	500-800	1,000-2,000
Motor	1,500-2,000	2,000-3,000	600-900	1,000-2,000

Most of the 10 boat owners are residents of Zanzibar. Two boat owners reside in Kizimkazi, one in each village. At any one time, two boats operate from Dimbani and six to seven from Mkunguni. There are a total of 16 motor boats but only eight to nine are simultaneously in service. Each observation trip earns about TSh20,000. The earnings are divided as follows:

- pilot and captain TSh1,500 each;
- petrol TSh4,000;
- village share TSh500;
- tax (15%) TSh3,000;
- boat owner TSh9,500.

In theory, the captain keeps the money owed to the boat owner for one month to cover any repairs that might be required. There is some question whether this really happens. About 30 villagers are involved in transporting the tourists. Approximate monthly revenues are summarized in Table 3. Data collection was not conducted on a few days so the figures are minimum estimates.

Fishers in both villages, especially those who are older and those who live in Dimbani, prefer fishing to the tourist trade. However, the approximately 30 fishers who are involved in dolphin tourism find it a reasonable alternative, especially during the high tourist season. It offers some variety and, especially for the younger fishers, it is an opportunity to socialize with foreign visitors. It also is more dependable income than a fishing trip that depends on the catch. A dolphin trip guarantees Tsh1,500 to each fisher. All of these men switch back to fishing during the low tourist season.

Table 3. Gross monthly revenues (TSh) from dolphin tourism

Month	Days/ Month	Captains N=15	Pilots N=15	Owner N=10	Village	Taxes
May	25	37,500	37,500	237,500	12,500	75,000
June	28	42,000	42,000	266,000	14,000	84,000
July	78	117,000	117,000	741,000	39,000	234,000
August	187	280,500	280,500	1,776,500	93,500	561,000

The economics of fishing with a motor boat

The initial investment for motorized fishing is almost the same as for dolphin tourism since the same vessels can be used for both purposes. A major additional cost can be the fishing gear. Nets, complete with floats and ropes, cost about TSh200,000 and two are required per boat. The cost of monthly net repair averages TSh5,000. The boat owner usually covers this cost. Hooks and fishing lines are usually bought by the fishers and are inexpensive. All Mkunguni boats serve the dual purpose but in Dimbani only two of the approximately 10 fishing boats are used for dolphin visits.

Motorized fishing offers several advantages. It allows the fishers to exploit a larger area, reduces travel time and enables them to use a seine. However, the fuel cost is significant and if the fisherman catches nothing, he is left with a debt of about TSh4,000 to pay for the petrol.

Small catches of little fish are sold to the local fishmonger to pay for the petrol. If larger fish are caught, the fisherman will often travel with other fishers to the markets in Zanzibar Town or, for the highest prices, Dar es Salaam. Money from

the sales is first used to pay for petrol. Remaining funds are split 50:50 between fishers and the owner. If the catch is very small, the boat owner usually receives nothing.

The economics of *ngalawa* fishing

The outrigger-dugout canoe (*ngalawa*) is the most popular non-motorized fishing vessel for the approximately 300 fishers of Mkunguni and Dimbani. The dugout hull, made from a single tree trunk, is long and thin. It is stabilized by outriggers on either side and propelled by hand (long poles) or sail. The project has counted about 64 dugout canoes.

A large dugout canoe costs about TSh300,000; a small one costs TSh200,000. Additional costs include nets and other equipment. As with the motor boats, these expenses are covered by the owners. Although these vessels are much cheaper, most fishers can still not afford their purchase. The local fishmongers own most of these vessels. There are about seven to ten fishmongers in Kizimkazi.

The dugout canoes are rented to the fishers under a variety of agreements. The most common understanding is that in the event of no catch, there is no rental cost. If there is a catch the fisherman sells it to the fishmonger at a much lower price than he would get at market. It is difficult to estimate the income of the fishers, given daily and seasonal variability in catch, but it appears that while they earn enough to feed and clothe the family, there is little left over.

The social impact

Ten years ago, the remoteness of the two villages meant that most of the villagers had not encountered many foreigners. When one was seen, the children were usually terrified and the adults hesitant. Today foreign visitors are a part of their daily life, resulting in major social and economic upheaval in the village (Table 4).

Table 4. Numbers of boat trips and tourists, May-August, 1997 (numbers approximate, not all days observed)

	May		June		July		August	
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
Trips/day	3	0-4	2	0-6	4	0-12	8	1-17
Tourists/day	13	0-21	10	0-20	26	0-70	53	4-121

Firstly, the introduction of the motor boat generated more income from fishing and dolphin tourism. This was followed by the building of the guesthouse in

Mkunguni three years ago. It now provides employment and encourages tourists to stay longer and spend more time in the village. With the increase in tourist traffic, more supplies such as petrol were needed; thus transport between Zanzibar town and Kizimkazi increased to several times a day from once or twice a week, substantially improving communications. The added income and improved communications has in turn led to the introduction of luxury goods. Common among the goods now found in Kizimkazi are televisions, a few video machines, confectionery, and, sadly, abusive substances like drugs and alcohol.

The dolphin tourism has led to many business "spin-offs". There are three new restaurants (including the guesthouse). Several people are making and selling woodcarvings of boats and dolphins. Some are selling fruit and *madafu*, a local "sweet". A school library was built from tourist donations to a "charity" box. The related businesses also include the less environmentally friendly trade in shells and one individual who has set up a bushbaby park in appalling conditions. The trade in abusive drugs has also increased and attendance at school has decreased, as many children prefer to cater to the tourists, selling fruit or begging.

The psychological impact of these rapid changes has apparently been to undermine the traditional social structure in the villages. This is most evident among the young. Previously, the main form of entertainment was conversation to exchange local lore and traditions. Now, television is more popular. Many of the young people, especially the young men, are no longer content to follow their fathers' fishing vocation and are leaving the village to earn their money in Zanzibar Town. Kizimkazi, once a very religious community, is witnessing many of the younger generation turn away from religion and turn towards substance abuse.

The dolphin trips themselves have also caused disharmony between villages. Village relations between Dimbani and Mkunguni, never cordial, have deteriorated because of Mkunguni's virtual monopoly of the dolphin trips. To shift some of the tourism business, the people of Dimbani recently erected a sign at the main road junction advertising cheaper trips in Dimbani. They also posted scouts to stop the tourist buses at the entrance of Mkunguni and encouraged them to go to Dimbani. As can be expected, this angered the people of Mkunguni such that days later a football match between the two villages ended in a large brawl.

RECOMMENDATIONS

The explosive growth of tourism in all of Zanzibar meant that it was only a matter of time before Kizimkazi would feel its effects but it is obvious that dolphin

tourism has sped up the process. Whether for good or bad, the change was inevitable. It is clear that within a few more years, the very essence of Kizimkazi will have changed. The aim of the Unguja Dolphin Project is to develop guidelines for safeguarding the dolphins. A successful management of the dolphin tourist trade will ensure continued visitors and income to Kizimkazi and hopefully, the people of Kizimkazi will find the means for converting these to positive change. We recommend the following rules and guidelines be implemented:

- no feeding of the dolphins;
- restricted swimming with the dolphins;
- no smoking in the boats;
- no drinking of alcohol in the boats;
- no littering;
- restrictions on the approach distance from dolphins, not to be exceeded unless the boat is drifting or dolphins choose to approach;
- restrictions on prices and observation time.

ACKNOWLEDGMENTS

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Section V: Fisheries and environmental management and policy at the National or Regional level

The role of the National Environment Management Council (N.E.M.C.) in artisanal fisheries conservation in Tanzania

Godlove U. J. Mwamsojo

INTRODUCTION

Tanzania is endowed with many lakes and impoundments. They range in size from the Great Lakes of Tanganyika, Victoria, and Nyasa, to the smaller Lake Rukwa, the Nyumba ya Mungu and Mtera reservoirs and the minor water bodies including rivers, swamps, small reservoirs, dams and flood plains. Approximately 61,500 km^2 (6.5%) of the area of Tanzania is covered by freshwater. Lakes Tanganyika, Victoria and Nyasa represent 88% of this total area (Welcomme 1979, Balarin 1985). The freshwater fishery resources are abundant and diverse. Nhwani *et al.* (1995) estimated 855 species of fresh water fishes in Tanzania. Lakes Tanganyika, Victoria and Nyasa are inhabited by more than 773 species, most of which are cichlids. Ninety-five percent of these are endemic to these lakes (Eccles 1992, Coulter 1991). The fisheries of the larger lakes and impoundments account for about 98% of the freshwater fishery.

Tanzania is also a maritime state with an 800 km coastline on the Western Indian Ocean. Tanzania's Exclusive Economic Zone (EEZ) extends 200 km from the coast. The continental shelf is narrow, often with a fringing coral reef. The reefs and numerous islands often form lagoons along the coastline. The rivers Pangani, Ruvu, Rufiji, Matandu, Mbwemkuru and Ruvuma form estuaries and, in some cases, deltas. Mangroves are common features in most of the estuaries while seagrasses and corals are common in the intertidal and subtidal areas. More than 1,000 fish species have been reported from the marine waters of Tanzania (Benbow 1976). Marine and freshwater fisheries contribute 13% and 87% respectively of the total catches.

Little is known about the size of the fishery resources in Tanzania, partly owing to the lack of stock assessment research. The only available information is based on FAO studies conducted on Lake Victoria (Welcomme 1979) and the marine expeditions conducted aboard the RV *Professor Metsyatsev* and RV *Dr. Fridtjof Nansen* (Gulland 1979, Inversen *et al.* 1984). The marine expeditions indicated a potential trawl yield of 25,000-44,000 t and a biomass of 100,000-175,000 t. However, the two surveys explored demersal stocks only. The reef and pelagic

fishery were not explored. Bwathondi (1990) reported that the potential biomass of fish in Tanzania for both marine and fresh water was 730,000 t. Current annual catches are less than 400,000 t.

The importance of artisanal fisheries in Tanzania

The artisanal fisheries use locally made fishing gear and vessels. The gear includes gillnets, castnets, traps, hooks, seine-nets, spears and a "beat-and-chase" technique (*katuli*). Molluscs and echinoderms are collected by hand. Artisanal fishing vessels vary from simple dugouts, to dugouts with outriggers and planked boats. Few fishers own modern wooden boats with engines. The simple vessels cannot withstand the rough conditions of deeper waters; therefore fishing activities tend to be concentrated in the shallow nearshore waters. In addition to finfish and shellfish fisheries, seaweed farming supplements the economy of artisanal fishers especially on Unguja Island.

Despite the fact that artisanal fishers operate with minimal investment capital and primitive equipment, their fisheries provide most of the fish protein, income and employment to the people living near the lakes and ocean. Bwathondi (1990) reported that more than 64,000 full time and about 300,000 part time fishers were engaged in fishery related activities, including net mending, boat building and engine repair, and fish processing, distribution and marketing. The artisanal fisheries contribute more than 99% of the fisheries catches.

Table 1. The trend of catch statistics (% weight) for both artisanal vs. commercial fisheries and freshwater vs. marine in Tanzania mainland for 1987-1994

Year	Source		Fishery		
	Fresh.water	Marine	Artisanal	Commercial	Total (t)
1987	89.0	11.0	99.5	0.5	342,291
1988	88.3	11.7	99.5	0.5	395,122
1989	87.3	12.7	99.6	0.4	376,849
1990	86.6	13.4	99.7	0.3	412,569
1991	83.9	16.1	99.6	0.4	325,961
1992	87.4	12.6	99.6	0.4	334,961
1993	89.6	11.4	99.6	0.4	330,232
1994	86.0	14.0	99.3	0.7	267,077
Average	87.3	12.7	99.6	0.4	348,127

The state of the aquatic environment and threats facing artisanal fisheries in Tanzania

Although it can be argued that the aquatic environment of Tanzania is relatively intact, the fishery habitats have been significantly degraded and are threatened by various anthropogenic activities. The most important of these threats can be

grouped into three categories: physical damage, water pollution, and resource depletion. Agricultural activities such as tilling and the application of pesticides and fertilizers are responsible for the increase of non-degradable agro-chemicals and siltation in the water. Overgrazing and deforestation have lead to increased sediment load in the rivers, lakes and reservoirs. It is estimated that about 40-60% of the forest along the central portion of the shores of Lake Tanganyika has been cleared, while in the north the harvesting is nearly 100%. These activities increase erosion by allowing the topsoil to be transported in the runoff to the streams, lakes and nearshore regions of the ocean. Suspended silt clogs fish gills, bleaches corals, buries seagrasses, and increases light attenuation in the water. These effects, in turn, lead to a loss of the benthic habitat critical to fish. In Lake Nyasa, for instance, *Opsaridium microlepis* spawns in silt-free upstream gravel areas. Destruction of this spawning habitat threatens the reproductive success of this species.

Solid and liquid waste pollution from domestic runoff or industrial and medical centres can contaminate fish habitat. Primary producers bio-accumulate heavy metals and other carcinogenic materials and transfer them to humans. This is especially likely for people who live close to towns like Mwanza and Kigoma.

Some fishing methods such as small mesh gillnets and seines, nets, poison, beach seining and trawling have all been blamed for contributing to overexploitation and decline of fish stocks. The introduction or invasion by exotic species can also lead to ecological instability and threaten the survival of indigenous species. The introduced water hyacinth (*Eichonia crassipes*) in Lake Victoria and the Pangani River is a nuisance to artisanal fishers. The plant forms floating mats that entangle and move surface nets. It restricts navigation and limits the amount of dissolved oxygen in the water. It sheds large amounts of organic litter which, when decomposing, increases the oxygen demand (BOD) of the water. Water hyacinth also provides breeding areas for mosquitoes and provides habitat for the snails that are vectors of the bilharzia parasite. The introduction of brown trout (*Salmo trutta*) and black bass (*Micropterous salmoides*) in highland areas of Iringa and Mbeya have possibly led to the extinction of knerid worms, and fish species of the Amphiliidae and Cyprinidae families in those streams.

In addition to the siltation and pollution mentioned above, the nearshore marine area is threatened by the clearing of coastal forests, conversion of mangrove swamps to salt production, extraction of sand and corals, unregulated tourism, shell collection, and urbanisation along the coast. These all act to reduce the ecological viability of fish habitats. Fishing practices like blastfishing, trawling and beach seining are responsible for physical damage to marine habitats and over-exploitation of the fishery resources. All these destructive activities threaten the sustainability of the artisanal fishery.

Economic issues, which threaten the artisanal fishery, include inadequate processing methods and facilities. These result in post-harvest losses as well as threatening the marketing of the fisheries. For example, in early 1997, the European Union imposed an embargo on fish fillets from Lake Victoria owing to infestation of bacteria (*Salmonella* spp.). The infestation had resulted from poor hygienic practices.

The conservation role of the National Environment Management Council (N.E.M.C.)

The National Environment Management Council (N.E.M.C.) was established by National Environment Act No. 19. 1983. The general mandate of the Council is to assume advisory responsibilities on all issues related to the environment. The specific functions of the N.E.M.C. are:

- to formulate policy on environment management and advise on subsequent implementation;
- to coordinate activities of agencies concerned with the environment and provide a link between those bodies and the national government;
- to evaluate existing and proposed environmental policies and activities with the aim of controlling pollution;
- to recommend measures for the development and conservation of natural resources;
- to foster co-operation between Government and other agencies engaged in environmental management;
- to sensitise the public and private community about environmental issues and encourage their participation in programs and activities directed towards using the natural resources for optimal national benefit;
- to seek advancement of scientific knowledge about the environment and encourage the development of technology to prevent or minimize the adverse impacts on the environment;
- to specify environmental standards to encourage beneficial use and protect the quality of the environment;
- to develop and operate a system for documenting and disseminating environmental information;
- to propose and formulate environmental legislation;
- to liaise with other national and international environmental organizations;
- to perform any other such functions as the minister may assign or any functions which are incidental to the perceived functions.

To facilitate these activities, the Council established and is maintaining a system of collaboration, consultation and co-operation with any person or institution having functions related to environmental matters.

The N.E.M.C. and artisanal fisheries

In consideration of the importance of the artisanal fisheries sector in Tanzania, both economically and socially, and in view of the observed threats to these fisheries, the N.E.M.C. is committed to the protection of aquatic habitats. The objective is to ensure the development and sustainability of aquatic resources and protection of aquatic habitat.

Several initiatives have been directed at conservation of the artisanal fisheries and the monitoring and management of aquatic resource at the ecosystem level. The most important freshwater ecosystems for artisanal fisheries include the shores of lakes and rivers, reservoirs, swamps and flood plains. Critical marine ecosystems and biotopes include the coral reefs, seagrass beds, sandy-muddy flats, rocky cliffs and platforms, mangrove swamps, estuaries, and deltas. In addition to their productivity, these ecosystems are critical to artisanal fisheries because the small non-motorised traditional vessels have ready access to them. Therefore, any conservation strategy addressing the protection of shallow water ecosystems is useful for the protection of artisanal fisheries and aquatic productivity.

Environmental monitoring

Effective strategic planning and implementation requires adequate background information. In particular, aquatic resource management requires knowledge about the extent and impact of the destructive activities that threaten the aquatic environment. To meet this need, the N.E.M.C. co-ordinated a countrywide survey (conducted on a regional basis) to document these activities. The survey found that activities harmful to aquatic habitat common to all regions include agriculture, overgrazing, deforestation, destructive fishing methods, industrial development and poor waste management. The reports are in preparation and will provide a summary characterisation of the extent of destruction by region and will be used to design and prioritise strategies for managing the environment.

The N.E.M.C. is also compiling a list of natural resource conservation projects in Tanzania. The preparatory work is complete and summary reports are in preparation. This information will facilitate the activities of people working on environmental projects.

The N.E.M.C. has also coordinated a countrywide biodiversity study. A draft report has been submitted to the United Nations Environmental Program (U.N.E.P.). Currently the N.E.M.C. is collaborating with the Tanzanian Fisheries

Research Institute (TAFIRI) and the University of Dar es Salaam (U.D.S.M.) in implementing a World Bank funded project in Lake Victoria. This project aims to evaluate the impact of human activities on the chemical, physical, socio-economic and ecological environment of Lake Victoria and its catchment basin.

Environmental management

The N.E.M.C. has proposed a number of environmental management projects. Some are in the preparatory phase, some have been submitted to donors for funding, and some have received funding and are being implemented by various institutions in collaboration with the N.E.M.C. The Council has also drafted an environment policy to guide development activities that have environmental implications. The policy objective is to maintain or enhance the environment with respect to resource and social needs of the present and future generations. The draft policy is under review by the parent ministry before being forwarded to cabinet.

The National Wetland Program is coordinated by the N.E.M.C. Its main purpose is the formulation of wetlands policy and strategies (Bwathondi and Mwamsojo 1993). A draft policy is awaiting approval. The program has also prepared an inventory of all wetlands in Tanzania. An "Environment Protection" bill is in draft form and is awaiting approval and enactment by parliament. The resulting act will facilitate prosecution of persons found guilty of violating environmental regulations.

The National Conservation Strategy for Sustainable Development (N.C.S.S.D.) has also been prepared by the N.E.M.C. This document is designed to assess the environmental impact of proposed development projects. The main goal is to have baseline information and examine the fate of the environment after implementation of a project. It seeks to balance the economic gains against the sustainability of resources to ensure the perpetuation of the resource.

One of the responsibilities of the N.E.M.C., on behalf of the parent ministry, is to respond to any environmental incident involving the waters of the United Republic of Tanzania. To assist in meeting this obligation, the N.E.M.C. has prepared a National Marine Contingency Plan (N.M.C.P.). The Swedish International Development Agency (S.I.D.A.) and International Maritime Organisation (I.M.O.) funded development of this plan. The purpose of the N.M.C.P. is to facilitate information flow in response to environmental destruction so that appropriate remedial measures can be implemented more quickly. The N.M.C.P. recommends creation of a National Marine Pollution Organisation (N.M.P.O.) which shall be comprised of a National Marine Reporting Centre (N.M.R.C.) and a National Response Committee (N.A.R.C.O.). The main text of the N.M.C.P. is complete. Appendices

concerning sensitivity mapping, equipment lists, and contact personnel are still being prepared.

The Government of the Netherlands and the International Union for the Conservation of Nature (I.U.C.N.) jointly proposed the Rufiji Delta Wetland Management Plan (R.D.W.M.P.) to conserve coastal and riparian forests in the Rufiji Delta. The extensive mangrove forests of the delta are threatened by over-harvesting. These forests are important as nursery and feeding grounds for juvenile finfish and shellfish and are therefore critical to the productivity of the fisheries of the Mafia channel.

The N.E.M.C. has been involved in the preparing the Tanzania Coastal Management Partnership (T.C.M.P.) which will be funded by the United States Agency for International Development (U.S.A.I.D.). This project aims to formulate policies, develop guidelines, encourage development activities and support the district and national institutions engaged in the management of the marine environment.

The preparation of the Integrated Coastal Zone Management Programs has been completed. These include the Kunduchi Integrated Coastal Area Management Program (K.I.C.A.M.P.) which has been prepared and submitted to S.I.D.A. for funding. The N.E.M.C. is also assisting other current sub-programs on integrated coastal zone management in Tanzania. These include:

- the Mangrove Conservation Program funded by the Norwegian Government (N.O.R.A.D.) and the Tanzanian Forestry department;
- the Tanga Coastal Zone Management funded by the I.U.C.N. and the Irish Government;
- the Rural Integrated Project Support (R.I.P.S.) (Marine Protection Unit) under the umbrella of R.I.D.E.P. projects in Lindi and Mtwara regions;
- the Mafia Island Marine Park which is under the Tanzania Fisheries Department, World Wildlife Fund (W.W.F.) and N.O.R.A.D.

The purpose of the Mafia Island project is to protect the resources and habitat of the species-rich Mafia Channel. In view of its geographical location and morphological features, the Mafia archipelago is considered to be a fishery replenishment site for the southern and central parts of the Tanzanian coastal waters.

The N.E.M.C. also supports and seeks partnership with non-governmental organisations (NGOs), Community Based Organisations (CBOs) and environmental lobby groups engaged in the conservation of artisanal fisheries in Tanzania.

Problems in conserving artisanal fisheries

The N.E.M.C. encounters numerous problems in implementing conservation programs for the artisanal fisheries of Tanzania. Firstly, there is a lack of awareness among fishers about the possibility of depleting fish stocks if harvests are left uncontrolled. Most fishers argue that fishes are a God-given resource and can never disappear or become extinct because God is taking care of everything.

The common property aspect of fisheries also makes it difficult to implement conservation action. It is difficult to restrict or manipulate fishing activities when the people doing the exploiting have legally obtained licenses. This has led to increasing and uncontrolled fishing effort in shallow water where the stocks are decreasing. In some cases, the catches have been higher than the maximum sustainable yield (MSY) even though deep-sea stocks remain under-exploited.

With few exceptions, fisheries policy has emphasised strategies for increasing fish production, without emphasising conservation of habitats. The government enacted Act 6 in 1970, which permitted the creation of national marine parks and reserves. This led in 1975 to the following areas being gazetted as marine reserves: Mbudya Island, Bongoyo Island, Pangavini Island, Fungu Mkandya, Fungu Yasini in Dar es Salaam, Lantham Island, Mafia Island and the coral gardens (*Mwamba wa mbwa, Mwamba shundo and Fungu mnyama*), and Maziwi Island in Tanga (Kamkuru 1997, Pearson 1986/1987). However, park regulations were so poorly enforced, that Maziwi Island and Fungu Mkandya Parks have disappeared. Recently, in 1995, the fisheries sector in collaboration with W.W.F. established a marine park at Mafia Island following the enactment of marine park and reserves legislation No. 29 (1994).

The N.E.M.C. is the only agency that is charged with an advisory function to the government on issues pertaining to environment; however the council has no mandate for managing the environment. This is an operational obstacle that prohibits N.E.M.C. from directly intervening to stop environmentally unfriendly activities. The fisheries departments, which are charged with the mandate, lack the institutional capacity owing to the lack of adequate manpower, funds, equipment and appropriate technology.

Finally, it is difficult to assess the state of the aquatic environment owing to the lack of environmental standards or guidelines and the absence of a comprehensive strategy for conserving the aquatic environment. It is not possible to review development proposals or examine the effects of past developments without such guidelines.

RECOMMENDATIONS

The fishery sector provides protein and income to a significant proportion of the Tanzanian community but the rate of population increase demands that fish production keeps pace. However, in order to keep up, man is destroying the aquatic habitats essential for the fisheries. The aquatic resources are a natural heritage which, with other biota, have to be protected for future generations. Therefore conservation of artisanal fisheries is of paramount importance in Tanzania and we make the following recommendations:

- fisherfolk and the general public should be sensitised to the risks and consequences of mismanaging the fishery resources;
- to ensure more attention to the issue of common property, authorities charged with licensing and managing the fishery resource should work closely with the harvesters to ensure that fishing pressure is optimised to achieve sustainability of the resources;
- the fisheries sector needs to acknowledge the importance of incorporating into fisheries policy the conservation of aquatic and associated environments;
- the act which established the N.E.M.C. should be reviewed so that the Council can assume a supervisory function over environmental management;
- the institutional capacity of the fisheries sector should be improved to enable effective monitoring of the fishery environment;
- the link between extension workers at the district level and the directorate of fisheries should be improved;
- the fisheries sector should formulate guidelines and strategies for conserving aquatic habitats for the benefit of the nation;
- fish farming should be encouraged as an alternative occupation in properly selected sites, using cheap, appropriate and environmentally sound technology.

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Environmental conservation in the artisanal fisheries sector

Jabir Kassim Makame, Asha Ali Khatib and Haji Machano Ali

INTRODUCTION

Fisheries are the major socio-economic activity in Zanzibar waters. They provide employment in the coral rag coastal villages for men and women and almost all age groups. Most of the fishing is artisanal and is generally restricted to inter-tidal and shallow areas (Ngoile 1990). The principal fishing grounds are mangrove forests, sea grasses, sandbanks and coral reefs. A few fishers use light attraction and drift gillnets to exploit pelagic deep-water fishes. The coastal "fishable" belt on the east coast is narrow, generally less than three km wide, and exposed to large waves and strong currents (Ngoile 1990). The western side is broader and more accessible to fishers.

As the coastal population has increased, so has the number of fishers using this shallow water belt. This, in turn, has led to a decline in catch rates with their traditional gear. In an attempt to maintain their catch rates, fishers are switching to more efficient techniques including those that are destructive to the resources and the habitat. Seining, spearfishing, and blastfishing are becoming common in Zanzibar waters in spite of their use being prohibited by law.

Traditional management

There is a long history of traditional conservation or management in Zanzibar. These have included seasonal octopus closures in the southern Unguja Villages (Anon. 1994) and restrictions on nomadic (*dago*) fishing in Menai bay (Horrill 1992). They have also included the reservation of village-front fishing grounds for elders and the creation of special fishing areas that can only be fished to generate money for collective communal activities like special celebrations. These latter two forms have been in practice at Bweleo, Uzi, and Fumba.

Traditional resource management in most of these areas, however, was not sustained owing to a lack of support from formal authorities. Traditional management was disrupted by the continued incursions by outside fishers whose "home" fishing grounds were overfished and, in the southern villages, the lack of synchrony in octopus closures between bordering villages. The right of communities to implement conservation practices is now recognised in environmental legislation. This legislation provides strength to the current and proposed traditional management initiatives; however, the inter-village mixing of fishers on the fishing grounds requires better coordination to avoid conflict.

Coastal communities have realised the need to protect their resources from destructive exploitation but they lack an awareness of the legal aspects pertaining to such initiatives. Recent conflicts over fishing grounds in Chwaka Bay, Pongwe and Mtende, which involved traditional management, illustrate this lack of awareness.

Legal status pertaining to conservation in artisanal fisheries

The National Environmental policy of 1992 recognised the position of the local communities in resource exploitation and their role in conserving the resources. The policy stresses community participation in collaboration with NGO's and private organisations, in conserving resources and protecting the environment.

National environmental legislation emphasises this involvement and categorises programmes as being national, local, or community plans. All of these plans require co-ordination among and within the government agencies and communities. The National and local environmental plans, although established by the Government, require consultation with local resource users. The communities' plans, however, have to be run by the community in co-ordination with the Government institution responsible for that particular resource. The community and the Director of Environment shall determine the boundaries for these areas.

The Fisheries Department is the custodian of all marine-based products such as fish, sea weed, sea cucumbers, shells or any other ocean living organisms. Management of these resources and their environment is the Fisheries Department's task. The Fisheries Development Plan and the Fisheries Act of 1988 guide this task.

Fisheries legislature pertains to the conservation of marine organisms and their environment, and therefore contains warnings about the choice of fishing gears, loss of species, pollution, habitat destruction and preservation of marine products. It also emphasises community-based management systems of marine resources.

The role of the Department of the Environment

The Department of the Environment was established in 1989 with the following functions:

- to maintain a well organised environmental information bank;
- to provide environmental input into planning processes, based on the National Environmental Policy;
- to monitor the state of the environment and to organise environmental research;

- to address immediate environmental problems;
- to promote awareness of, and provide training in, environmental issues.

The Department has been organised into various units that focus on specific issues pertaining to the environment. These are Pollution Control, Natural Resources Management, Environmental Education, and Evaluation and Monitoring. The Natural Resources Management section is further divided into Terrestrial and Coastal zone management units. With respect to the artisanal fisheries, the role of the Department of the Environment is to bring together the conservation and fisheries management efforts of the different institutions. The major role of Coastal Zone sub-unit is to investigate the status and the use of coastal resources and the need for conservation. The Environmental Education Units focus on public participation campaigns and improving resource awareness.

Existing environmental conservation initiatives

The legal recognition has led to the emergence of local programs. These programmes are collaborative projects between the communities and the government institutions responsible for the particular resource. The government institutions provide an integrative and facilitative role in conjunction with a bottom-up approach to ensure community representation at all levels. Unlike traditional management, these initiatives assume a broader scope towards conserving resources. They hope to manage the ecological processes that govern the resources. This goal is achieved through different activities depending on the overall aim of the project. Artisanal fisheries management is one component in these initiatives. These various community projects include the Menai Bay Conservation Area Project, the Misali Island Nature Conservation Area Project, the Chwaka Bay-Paje Demonstration Project for Coastal Management, and the Jozani-Chwaka Bay Conservation Project

Menai Bay Conservation Area Project

The purpose of the Menai Bay Conservation Project is to create and manage the Menai Bay Conservation Area. The objective is to "conserve in perpetuity, the biological processes, ecological processes and productivity of the Menai Bay area and associated ecosystems to ensure resources are sufficient for local people to maintain their livelihoods".

This initiative originated with the community around the Fumba peninsula and then was expanded to the rest of the Menai Bay area. Representation starts at the level of village committees and includes district and village representatives in steering committees. This ensures local participation at all levels in planning and implementation of project activities. The Sub Commission of Fisheries facilitates

this programme with support from the World Wildlife Fund (W.W.F.). Collaborating institutions are the Department of Environment and the Institute of Marine Sciences (University of Dar es Salaam).

The project has numerous activities related to the artisanal fisheries. The first involves the restricting of fishing time for non-residential (*dago*) fishers. This activity is based on the assumption that resident fishers of the area have little negative effect on resource productivity. The second is banning the use of destructive fishing techniques, such as drive-net fishing (*kigumi*), beach seining (*juya*) and blastfishing. The villagers enforce the prohibitions with patrol trips, supported by the Commission of Natural Resources, the anti-smuggling department of the coast guard (K.M.K.M.) and the Department of Environment.

The third initiative involves field studies and monitoring. A field study (Horrill 1992) was conducted to investigate community claims about the status of the resources and thereby provide the basis for the management. A baseline survey was also conducted to provide quantitative data on the "before" status of the population (Horrill *et al.* 1994). A local monitoring programme was also designed and tested. The intent of the monitoring is to use fishery data collected from local fishers to derive estimates of catch rate and average size. These data can then be used to evaluate the impact of the project over time.

Finally, an environmental awareness programme is being developed based on Participatory Rural Appraisal (PRA) studies of three villages in the area (Kizimkazi Dimbani, Unguja Ukuu, and Ng'ambwa).

Chwaka Bay-Paje coastal management demonstration project

The purpose of the Chwaka Bay-Paje project is to provide a starting point for addressing the coastal issues of this area. It is also hoped that the results will be used as a basis for planning informed discussion on these problems on a nation-wide basis.

This project is facilitated by the Coastal Resources Management Council (C.R.M.C.) through a interagency planning team led by the Department of Environment and consisting of individuals from the Sub Commissions of Fisheries and Forestry, Commission of Lands and the Environment, and I.M.S. Villages involved in this project include Chwaka Marumbi, Uroa, Charawe, Ukongoroni, Michamvi, Bwejuu, Paje and Cheju. Community participation is ensured by the C.R.M.C. Representatives sit on the various sub-committees assigned to different tasks, such as:

- sustaining and enhancing village quality of life;
- conservation of critical habitats;

- fisheries management;
- zoning and management of seaweed farming;
- coastal forest management;
- coastal tourism management.

Artisanal fisheries conservation is addressed in two elements of the Ckwaka Bay-Paje project (Issa *et al.* 1996). These are conservation of the critical habitats that act as a resource base for artisanal fisheries and the regulation of fishing activities in these habitats. A series of strategies were developed to assist in reaching these goals and include:

- fostering the sustainable use of critical coastal habitats such as mangrove forests, coral reefs, sea grass beds, beaches and coastal thickets;
- establishing baseline information on the coastal habitats from which change can be measured and future management decisions can be based;
- formulating monitoring parameters/protocols that are rapid, appropriate, and easily repeated.

Strategies to assist management of artisanal fisheries include:

- preparing programs to assist management of artisanal fisheries;
- halting the decline of fish catches and populations and restore resources to sustainable levels;
- testing community-based management strategies as mechanisms for addressing multiple fisheries and complex habitat issues;
- assessing the feasibility of exploiting offshore fisheries, and the potential impact of introducing more efficient gear for the inshore fishery;
- promoting the resolution of inter-village conflicts over the use of destructive fishing gear.

Building from these strategies, the short and medium term priorities are:

- reducing environmental degradation by improving awareness among villagers, tourists, hotel operators and government officials about the importance and fragility of critical habitat systems in the demonstration site;
- establishing baseline monitoring programs or enhancing existing monitoring programs on the coastal habitats using indicators/protocols that are rapid, relevant to key stakeholders, easily repeated and utilise resource users for data acquisition;
- improving community involvement in planning and decision making (especially important owing to the dramatic growth in tourism);

- encouraging dialogue among conflicting users to foster co-operation (as the number and variety of users rises in the demonstration site, co-operative efforts for minimising user conflicts must be developed and implemented).

Misali Island Nature Conservation Project

The Misali Island Nature Conservation Project was designed to conserve biodiversity in the area of Misali Island consistent with the promotion of ecotourism. The Commission facilitates the conservation initiatives for Natural Resources through the Environmental and Development Group (U.K.). This project will be elevated to a nature conservation status rather than a community programme. The "bottom-up" approach will be used in the implementation of the activities with an emphasis on participation of local stakeholders in the planning process. This island is not consistently inhabited but is used by fishers in their seasonal camps.

Consultation seminars have revealed that the local communities agree with the idea of promoting Misali Island and its adjacent waters as a multi-user conservation area. They suggest that the Island should remain publicly owned and not leased to foreigner or local investors. The seminars also proposed that:

- fishery, tourism and other activities should be monitored and controlled (in particular, the existing camp permit system for Misali Island should be continued. However, all permits should be initially requested from heads of the nearby villages (*Shehia*) and then passed to the commission for Natural Resources or the appropriate institution responsible for natural resource management);
- education programmes on conservation should be developed by the Misali Island Conservation project for all Misali Island users;
- the Misali Island Conservation Project should have responsibility for reviewing all initiatives which relate to development in the nearby communities and the conservation of Misali Island.

During the current start-up phase, the project is concentrating on submission of the draft legislation and a management plan to the Minister to declare Misali Island a conservation area, as well as confirmation of committee structures and appointment of members (local/district committees and management committee members).

Jozani-Chwaka Bay conservation area

The focus of the Jozani-Chwaka Bay conservation area project is forest management, particularly in the Jozani Forest, Chwaka Bay mangroves and Unguja Ukuu forest plantation. The project is not directly involved in fisheries

management but is fishery related owing to the partial focus on the mangrove ecosystem and therefore has an impact on fishery productivity. The project recognises this relation and provides for fishers representation in the management committees at the local level.

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Artisanal fisheries management in Tanga *Hassan Kalombo*

INTRODUCTION

The 150-km coastline of Tanga Region, which stretches from the Kenyan boarder in the north to Buyuni (Pangani) to the south on the border with the Coastal Region, faces many environmental problems (Fig. 1). Critical among these are declining fish landings, beach erosion and poverty. In 1987, at the request of the Tanga Region Authority, the International Union for Conservation of Nature (I.U.C.N.) conducted a survey to examine the status of the coral reefs. The concerns expressed in the report led, in 1994, to the establishment of the Tanga Coastal Zone Conservation and Development Programme. This programme is funded by Irish Aid with technical support from the I.U.C.N. The programme is within the Region Administrative Secretary's (R.A.S.) office that works with the three coastal districts of Tanga Region, Pangani, Muheza and Tanga Municipality. Phase One of the programme ended June 9, 1997 and was followed by the start of Phase Two in July of the same year.

The first step of the programme was to conduct a socio-economic study of the coastal area and then hold a regional workshop with all stakeholders to discuss the seven problems identified by this study:

- fish scarcity;
- low agricultural production (due to vermin);
- beach erosion;
- beach pollution;
- poor enforcement;
- scarcity of wood fuel and building materials;
- lack of social and economic services.

Three pilot villages, Kipumbwi (Pangani District), Kigombe (Muheza District) and Mwambani/Mchukuuni (Tanga Municipality), were chosen as test cases. People of these villages were then asked to identify which problems were the highest priorities. All three villages chose "fish scarcity" as the biggest problem. Government extension staff was then trained to facilitate a process of participatory analysis of this issue, its causes and possible solutions (Table 1).

The villages formed village committees to implement the proposals, especially the enforcement of regulations by village patrols (*Kamati ya Doria*). These committees became the focal point for planning and implementation.

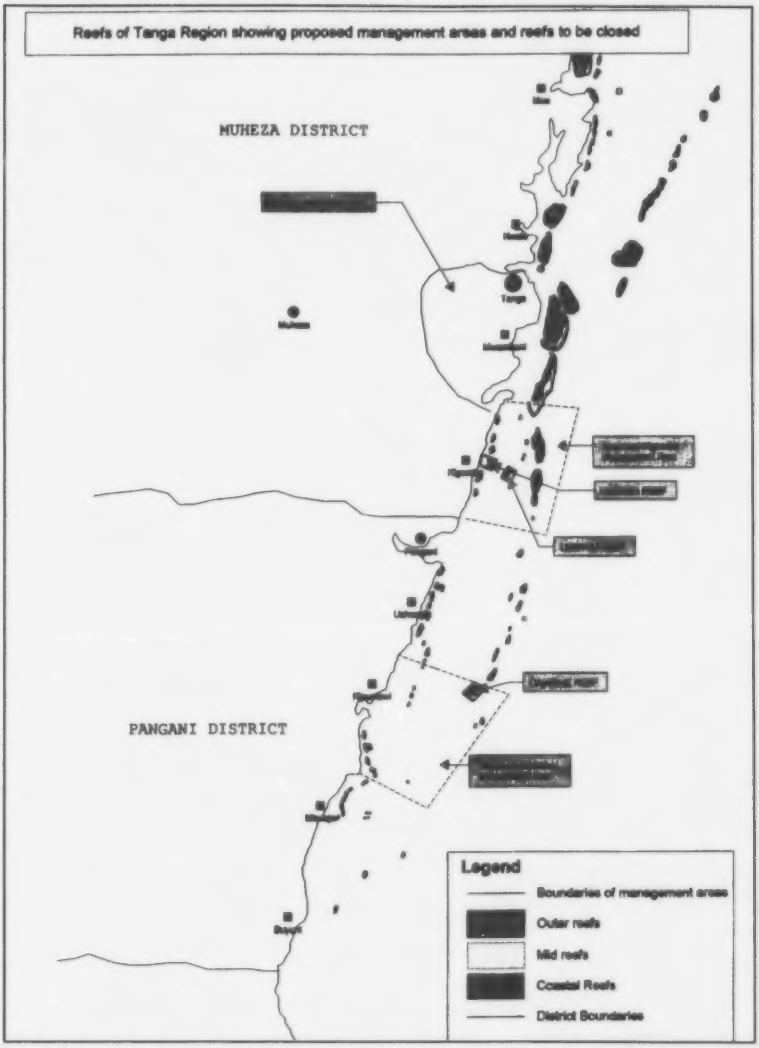

Figure 1. Map of project area

A study conducted by the programme has shown that these committees are representative of the various fisheries interest groups (Gorman *et al.* 1996). District personnel (Natural Resources Officers, Fisheries Officers and Community Development staff) and programme staff provided technical assistance to the village committees. The committees formulate objectives and identify the criteria for assessing success. They also produce action plans and activity schedules. Most of the activities relate to gear inspection, land and sea patrols, and education and awareness meetings. They also include advising the village governments on environmental protection measures such as reef closures and formulation of by-laws.

Table 1. Causes and possible solutions for declining fish catches

Issue	Causes	Solution
• declining catch	• illegal fishing techniques • uncontrolled mangrove cutting • destruction of coral reefs • inappropriate fishing gear • increased number of fishers, overfishing • trawlers fishing close to coast • seine nets, fishing of juveniles	• restrict illegal fishing techniques • plant mangrove • close areas to fishing • provide appropriate gears • develop alternative income sources • restrict trawlers to fishing offshore • encourage alternative gears • increase mesh size of nets

Paralleling this process, a participatory coral reef survey was conducted along the Tanga coast, to obtain information about the health and status of the reefs. The survey included mapping the location, type, extent and biophysical status of coral reefs in terms of the benthic cover, densities of selected benthic indicators, and target species. The study also compiled lists of coral genera and measures of fish community diversity and structure. The data were designed to serve as baseline information on the "state of the environment" and the starting point for development and analysis of management strategies.

The results of the survey were to:

- train six government officers in bio-physical survey techniques;
- train two government officers in participatory rural appraisal;
- identify and map 96 reefs (376 km) including 14 which had not previously been charted (reef formations mapped, in addition to the East African Barrier Reef, included coastal fringing reefs (41), and inner (30) and outer (25), adjacent to shelf, patch reefs);
- map the 407 km of the overall coastline, of which 199 km represented bays and estuaries;

- survey 54% of the reefs to assess benthic cover and densities of selected indicators (85% were surveyed for fish community structure and 94% for coral diversity);
- find that 10% of reefs were completely destroyed, 20% were in good condition, the remaining 70% were in poor to moderate condition;
- observe that the majority of reefs, found to be destroyed or in poor condition, were adjacent to areas of high population density (reefs in relatively good condition were adjacent to areas of low population density);
- observe that fish densities of reefs are relatively low in all but 10% of the reefs (highest fish densities were found near areas of low human population density);
- observe that coral diversity is highest on outer patch reefs (median = 27 genera, maximum = 39 genera).

With respect to the last item above, it is worth noting that coastal fringing reefs and inner patch reefs have about the same number of genera. Highest coral diversity was found at Maziwe and Fungu la Zinga. Coastal and inner patch reefs are both influenced by high sediment loads. Highly damaged reefs have very few genera. Nyuli and Ras Nyamakuu, for example, have only eight and four genera, respectively.

Fisheries Management

Fisheries management agreements were developed in the two pilot villages of Kigombe and Kipumbwi. The process used in Kigombe, described below, details the basic process for both villages (Horrill *et al.* 1997).

Programme and district staff first facilitated a series of meetings in which programme staff communicated the coral reef survey information back to all users. In this meeting, users discussed and modified the information. This information included:

- reef status;
- fish population status;
- coral diversity;
- which villages use the reefs;
- the importance of the reef for different fisheries;
- fishing gears;
- fish species.

Users then defined the area in which management action would be implemented and who needed to be involved. Management committees developed the principles of management which were to be applied and users developed the overall management objective, purpose of the action plan, results and indicators.

The users identified, analysed and agreed upon the action plan. Specific actions included:

- reef closure where special rules applied to closed areas (general rules applied to the larger areas);
- experimentation with fish aggregating devices;
- trial exchange of seine nets;
- identification of actions to restrict trawler fishing.

Village management committees also:

- defined enforcement rules, responsibilities, penalties, and the training that would be required for effective enforcement;
- defined programmes for monitoring and review including designating responsibilities and training requirements;
- identified the information networks and mechanisms.

In meetings with the villagers and village governments of Mwarongo and Tongoni, the village committees presented their management objectives, actions and expected results. Particular attention was given to the closure of Kitanga and Upangu reefs. Each of these villages approved and supported the closure of these reefs.

After the objective and main results of the plan were formulated and the choice was made as to which reefs to close, the users gave their management committee the mandate to develop the full details of the plan. This final plan was then discussed and approved by users and local governments of all villages that used the reefs. Minutes and attendance were recorded at each meeting. Of those meetings attended by users, an average of 91 villagers attended. This represented approximately 91% of the resident fishers. Ninety-one percent of these were male. An average of 28 committee members attended the meetings. These included all members of *Kamati ya Doria* plus members of other committees. At committee meetings, 75% were male. District staff attendance averaged five persons per meeting. A separate study conducted by the overall programme showed that most villagers are aware of, and support, the action plan (Gorman *et al.* 1996).

After presentation of the survey information, there was a discussion on whether further actions, other than enforcement, were needed to achieve the overall objective. A number of suggestions were forwarded, including no further action, gear restrictions and reef closures. It was subsequently agreed that gear restrictions were necessary to control impacts of small mesh nets on fish populations. The villagers then examined the benefits and disadvantages of reef closures (Table 2).

The villagers recognised there were a number of longer-term benefits to be realised from reef closures as well as the disadvantages of increased fishing pressure on remaining reefs and decreased income. The majority of villagers, however, did not see these major disadvantages since the reefs were already overfished. The price of fish tended to rise in times of scarcity and the use of fish-attracting devices may compensate for the loss of fishing area. As a result, 95 fishers voted in favour of closures while 45 voted against.

Table 2. Analysis of the benefits and disadvantages of reef closures

Advantages	Disadvantages
• fish in closed area will be able to grow to larger size and therefore produce more eggs; • reef condition will improve thereby increasing the amount of fish habitat; • number of fish in the closed area will increase; • fish will migrate and help populate open reefs.	• the overall fishing area will be restricted leading to overfishing of open areas; • fisheries income will decrease with decreased catch because of overfishing.

Crucial steps taken in closing areas to fishing

The next steps were to analyse the benefits and disadvantages of closures, determine the length of time of the closures and determine which areas were to be closed. The benefits and disadvantages of long and short-term closures were summarised (Table 3). Fishers favoured longer-term closures of at least one year to allow fish stocks to increase in number and average size and thereby provide increased productivity so that populations outside the closures might benefit. The longer closures would also provide time for the health of the reefs to improve. The villagers did not perceive that these results could be achieved by short-term closures of less than a year.

Table 3. Advantages and disadvantages of short term and long term closures

Term	Advantages	Disadvantages
• short term (6 months)	• quick answer for trial; • fish stocks may increase.	• fishers will suffer in short term; • fish will not have a chance to grow and breed; • fish stocks will not have sufficient time to increase; • reef health will not improve; • other reefs will be fished more; • once opened, many fishers will fish this area; • fish will be taken before they can migrate to neighbouring reefs.
• long term (≥ 1 year)	• stocks will increase in the closed area; • fish will get a chance to spawn; • fish will migrate to other areas.	• fisheries will suffer for a longer period; • other reef will be fished more for a long period; • once opened, many fishers will fish this area; • price of fish may reduce on opening.

Reef selection

Eleven reefs were considered for closure. Two additional reefs, Maji Viki and Funguni Tongoni, were eliminated from consideration because they were used by too many people. The 11 reefs were then scored with matrix analysis to examine the relative benefits of their closure. Each reef was scored from one to three against a set of predetermined criteria (Table 4). From this analysis, three reefs, Upangu, Kitanga and Kijamba Shamba, were selected for closure. Kijamba Shamba is actually an extension of Upangu reef so only two physically distinct reefs will be closed. The main reasons for these choices seem to be that they were easy to patrol and little used by other villages. Scores for other criteria did not differ markedly.

The management plans for the two villages have been sent to Fisheries Department to be gazetted and have been approved. In addition to these steps, village-based patrols are being conducted daily. These were initially assisted by the Marine Police but now are conducted solely by the villagers who have had militia trained so that they may use firearms during their activities.

Table 4. Analysis matrix to select which reef to be closed (reef names from left to right correspond to Kandacha, Kange, Chamboni, Upangu, Kitanga, Taa, Chanjale, Nyamvi, Kijamaba Shamba, Makome, Kijamaba Kai)

Reef criteria	Reef										
	K	K	C	U	K	T	C	N	K	M	K
number of types of fish (high=3)	2	3	1	2	2	1	2	3	1	1	2
strong currents (strong=3)	1	2	3	3	2	3	2	2	3	3	1
condition of reef (good=3)	3	2	1	2	3	1	2	3	3	1	3
importance (less important=3)	1	1	3	2	2	1	2	3	3	3	3
used by other villages (low=3)	3	1	2	3	3	1	3	2	3	1	3
easy to patrol (easy=3)	1	1	3	3	3	3	2	1	3	3	1
total score	11	10	13	15	15	10	13	14	15	12	13

The results of the ongoing land and sea patrols as of September 1998 are that about 12 boats have been confiscated for blastfishing and the number of blasts reported per day has declined from 20 to 0. Approximately 35 fishing violation cases are going in the courts and most of the beach seine operators have changed from a codend mesh size of 0.5 in. to 1.5-2.5 in.

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Discussion Summaries

For the final afternoon, participants divided into three discussion groups on (1) fisheries data collection, (2) current problems in fisheries management, and (3) fishery development and promotion. The results of the discussions were summarised and presented at the plenary session. Written summaries are included below.

Discussion Group #1: Fishery data collection summary

The comments of Discussion Group #1 were combined with summary statements on data collection by Mr. Rick Stanley. The discussion focussed on the general requirements of data collections schemes, specific data to be collected, and alternative data collection schemes.

General requirements of data collection systems

The group noted the need for good baseline data in order to monitor trends and determine stock status. These analyses also required an understanding of the seasonal variation of the resources and the fisheries. The Group noted that methods used to collect fishery harvest data needed to be reviewed and be adequately funded. In particular they noted that:

- sampling sites need weighing scales, stationery and calculators and access to shade for weighing of fish;
- there should be al least two people to conduct sampling in sites;
- the capacity of the personnel should be increased by providing better training and proper incentives to increase moral;
- bycatch should be reported;
- market studies should be conducted;
- the fishing community should become more involved in the collection of data and become more responsible users with regard to restricting or eliminating use of non-selective and destructive gears, especially in sensitive areas;
- fisheries monitoring would be improved through upgrading of fishery regulations.

Specific data to be collected

The Group noted that primary collection of catch data should include:

- species to at least level of family and, where possible to species, especially for Scombridae (tuna and mackerel);
- total catch weight;

- number of fish, when possible;
- size composition;
- number of fisherfolk per vessel;
- departure and arrival time;
- time spent fishing and travelling;
- name and location of fishing ground;
- gear types and details (number of lines, bait, trap type);
- vessel type;
- registration no.;
- price paid for catch;
- fish retained for home consumption;
- costs of fishing.

Alternative data collection methods

The Discussion Group noted the need for information on the bycatch of turtles, dugong and dolphin. These data could be collected through interviews, direct observation or waste counts (carcasses or carapaces). Fisheries literature should be reviewed to assess alternative harvest monitoring methodologies. Many alternative methods were discussed during the presentations. These included :

- census coverage;
- frame surveys;
- sampling (partial coverage);
- counting of deliveries;
- observers on-board fishing vessels;
- fisherfolk logs;
- underwater visual censuses (UVC);
- village interviews;
- surveys of household consumption;
- fishery surveys for estimates of biomass, catch-per-unit-effort and bio-diversity;
- marketing and price surveys.

It was emphasised that no one data collection procedure could answer all questions and therefore it was essential to carefully and rigorously define the objectives of the monitoring. The most effective monitoring studies often tended to combine various methodologies. The most effective programs were those which were actively supervised and continually evaluated.

Discussion Group #2: Future directions in fisheries management

Discussion group #2 identified a variety of future directions for Fisheries Management. These included Community Management, Gear Restrictions, Fishery Development and Promotion, and Public Education of Fisheries Conservation.

Community management

The group recognised that fisheries that exploit abundant stocks and incorporate few user-groups are easier to manage than fisheries that involve many user-groups. The group recommended:

- a detailed inventory of all examples of historic or current user-group management systems;
- a study of areas which no longer support user-group management to determine the reasons for abandoning the approach;
- the encouragement of traditional user-group management systems to include identifying those stakeholders willing to contribute to the process.

Gear restrictions

The group recognised that drive-net (*kigumi*) and blastfishing techniques are destructive and illegal and should be vigorously discouraged. The group recommended:

- increased enforcement and surveillance possibly through increased involvement of other government authorities such as the Army and the Marine Police;
- immediate confiscation of illegal equipment;
- targeting fishing communities which consistently use illegal methods with extension work to educate the community on the impact of destructive techniques and discuss effective alternatives;
- increased information exchange between different areas regarding the effectiveness of enforcement;
- development of an enforcement database;
- more rapid processing of fines and charges related to fishing offences.

Fishery development and promotion

The discussion group emphasised that fishery development could be promoted to achieve positive benefits while minimising the negative impacts. The group recommended:

- increased education to improve post-harvest handling and processing;
- increased research on aquaculture;
- research on potential fisheries within the EEZ, especially the pelagic resource;

- improved data collection;
- improved fish processing and storage infrastructure;
- development of cost-effective fish processing technologies such as fish-smoking.

Public education on fisheries conservation

The discussion group emphasised the need to improve public awareness regarding fishery conservation. The group recommended:

- greater use of the media (TV, radio, press) (the group noted that free advertisements were available in newspapers and TV);
- development of environmental/fisheries information in public school curricula;
- encouraging exchange of information among fisherfolk from different areas to discuss common problems;
- encouraging dialogue with the fishing community prior to implementation of regulations and involve them in decision-making.

Increased government funding

The group noted that fisheries management is severely hampered by a lack of government funding and that the Fisheries Departments should endeavour to be better advocates for their own activities and increase their lobbying effectiveness. The group recommended:

- that the Fisheries Departments provide better justification for their funding and resource requirements;
- that Fisheries Departments be allowed to retain funds collected from licences or fines;
- that Fisheries Departments focus on developing a greater awareness of fisheries conservation issues in more senior government levels, such as Parliament, as well as other Departments through seminars or presentations.

Marine Protected Areas

The group suggested that increased use be made of Marine Protected Areas (MPA's) in fishery conservation. The group noted that:

- MPA's can be an source of funds, such as through tourism licensing, which can be used in fisheries management;
- MPA's can help protect specific habitats such as coral reefs for breeding areas which will benefit reef fisheries in general;
- MPA's serve as a useful tool in promoting fisheries awareness and the need for conservation, especially among children;
- MPA's provide employment opportunities through tourism thereby reducing the fishing pressure, especially in coral reef areas.

Discussion Group #3: Current problems in fisheries management

Discussion Group #3 commented that current management is hindered by a lack of information on resource abundance and status (absolute and relative estimates of abundance). The group noted, however, that even if this information were available, management would still be constrained by a lack of trained manpower, funding and the absence of well defined policy. Recommendations focussed on funding, enforcement and conservation, fisheries development and data collection, and the slow response time of government bureaucracy.

Funding

The group acknowledged the difficulty of implementing rational management within a poor economy and amid widespread poverty, nevertheless, such management is essential for the well being of the Tanzanian society, therefore the group recommended:

- altering legislation to provide for a retention scheme which allows revenue collected within the fisheries sector be retained to develop the sector.

Enforcement and conservation

The group noted the widespread use of non-selective and destructive gears (trawl nets, beach seines, drive-net fishing) and the laxity in fisheries enforcement owing partly to the lack of fisheries patrol vessels and personnel, and recommended:

- updating fisheries legislation so that heavier punishments can address fisheries infractions;
- providing an adequate number of officers and patrol boats for surveillance and enforcement;
- prohibition or restriction of destructive or non-selective gears;
- encouragement of community-based management.

Fisheries development

The group noted that additional resources should be allocated to the traditional fisheries sector consistent with its social and economic importance, and recommended:

- improving the credit facilities for development of alternative fishing methods and improved processing and marketing infrastructure;
- increasing community teaching to upgrade fisheries technology and processing and marketing infrastructure;
- encouraging alternative fishing methods and use of under-utilised resources such as deep-sea fisheries or aquaculture.

Data collection

The group acknowledged the highly complex multi-species and multi-gear nature of the fishery and the problems this causes for collection of catch data, nevertheless, group discussions emphasised the need to improve this information and recommended:

- collection of better quality harvest data;
- initiation of incentive schemes for data collectors.

Summary comments from the closing plenary session

Workshop participants endorsed discussion summaries, which recommended among numerous items, that there must be better collection of landings and economic data from the fisheries. Without effective data collection, analysts will not be able to provide the information needed for sound planning and management. Workshop participants also emphasized that current regulations must be enforced, especially those which restrict use of non-selective or destructive fishing practices. Improved enforcement, in turn, requires more effective fisheries patrol, and increased community education with regard to environmental and fishery issues. Finally, fisheries management policy must include promotion of traditional management in the villages, increased use of incentives to develop the offshore fishery, improved marketing and cold storage infrastructure, and expanded use of marine protected areas.

Participants stressed that there are numerous fishery resource issues that cannot wait any longer for remedial action and urged government and non-governmental agencies to press for action. All agreed that there are numerous initiatives underway which will address many of these issues.

Participants commented that the well-organized workshop was successful in providing a valuable forum for presentation and discussion of current programs in fisheries research and management in Tanzania. The workshop helped to provide an improved basis for achieving progress in the collection and analysis of data essential for understanding the dynamics of Tanzania's fishery resources. It also was successful in drawing attention to the general issues of fishery research and management.

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Additional papers presented but not submitted

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